TRANSACTIONS OF THE

American Foundrymen's Association

Proceedings of the

Twenty-second Annual Meeting

BOSTON, MASS.

Sept. 24 to 28, 1917

VOLUME XXVI

Edited by

A. O. BACKERT
Secretary

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Cont sub

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OF THE

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J. P. PERO
President American Foundrymen's Association, 1916-1917

John P. Pero

JOHN P. PERO, the eighteenth president of the American Foundrymen's association, was born in Waltham, Mass., Dec. 9, 1856, and belongs to a family that for three generations has been prominent in the foundry business in New England.

When 10 years of age Mr. Pero moved with his parents to Worcester, Mass., where he finished his common school education, and after two years spent in the Worcester high school, he was indentured as an apprentice to learn the molder's trade on Feb. 1, 1870, at the age of 13 years, and has advanced step by step until now after 48 years' continuous service, his thorough knowledge of both the technical and practical details of the foundry business, together with his wide experience, places him in a prominent position among the leading foundrymen of the country.

In his early years he worked as a general molder in Worcester, Springfield, Fitchburg and other cities in Massachusetts and New England. In 1882 he accepted his first foremanship. From that time on his advance has been steady and in the period between 1883 and 1905 he was either foreman or superintendent of foundries of some of the largest concerns in New England, including Yale & Towne Mfg. Co., Stamford, Conn., and the Malleable Iron Fittings Co., Brantford, Conn.

In 1905, Mr. Pero moved to Brantford, Ont., to manage the Canadian malleable plant of the Pratt & Letchworth Co. In 1909 he entered the employ of the Missouri Malleable Iron Co., with which concern he is still connected in the capacity

of general superintendent. In addition to managing the operation of the plant, Mr. Pero devotes considerable energy to the business activities of the company.

Mr. Pero has made a special study of the metallurgical and commercial branches of the malleable iron industry. His studies have been backed up by many years of practical experience with the result that he is one of the leading malleable iron authorities in the country.

While in the employ of the Yale & Towne Mfg. Co., Stamford, Conn., Mr. Pero conceived the idea of an association among foundry foremen, and receiving encouragement from many foremen with whom he discussed the matter, he performed the preliminary work which culminated in the organization of the first technical association of foundrymen in this country in December, 1887. It was known as the New England Foundry Foremen's association. Mr. Pero served as secretary of the organization for several years. He also was instrumental in organizing the St. Louis Foundry Foremen's association and has been closely identified with the work of technical organizations for many years.

He has been prominent in the work of the American Foundrymen's association and has given special attention to the development of the activities of this organization in the malleable iron field.

He is prominent in municipal affairs of his home city, East St. Louis, is a member of various clubs and other organizations, including the Missouri Athletic association of St. Louis.

Summary of the Proceedings of the Twenty-Second Annual Meeting

Boston, Mass., Sept. 24 to 28, 1917

At the time the twenty-second annual meeting of the American Foundrymen's association was held, all branches of the foundry industry were working at top speed on war preparations. Nevertheless the importance of the meeting was such that a record-breaking attendance was attracted to Boston for the five days commencing Monday, Sept. 24, and ending Friday, Sept. 28. The one-session-per-day plan, which was inaugurated at the Cleveland meeting in 1916, was continued with evident satisfaction. Eight technical sessions were held. The session on Monday was conducted jointly with the American Institute of Metals. There were two steel sessions on Thursday and Friday, respectively, and one malleable session on Wednesday, Sept. 26. In addition, general topics were considered on Tuesday, cost-keeping and general topics on Wednesday, gray iron on Thursday and general topics on Friday. The registration was 775 men and 225 ladies, the total being exactly 1000.

Joint Opening Session

Monday, Sept. 24, 3:00 p. m., Paul Revere Hall

The convention and exhibition were formally opened jointly by a flag raising ceremony at 3:00 p. m., Sept. 24, in the Grand Hall of the Mechanics' building. This ceremony, which was conducted by United States marines, was repeated each day throughout the week. After listening to a brief speech of welcome from the stage of Grand Hall, the members of the American Foundrymen's association and the American Institute

of Metals adjourned to Paul Revere hall for the opening session.

J. P. Pero, president of the American Foundrymen's association, occupied the chair.

An address of welcome was delivered by the Hon. James M. Curley, mayor of Boston. Response was made on behalf of the American Foundrymen's association by R. A. Bull, Duquesne Steel Foundry Co., Pittsburgh.

J. P. Pero, president of the American Foundrymen's association, then presented his annual address in which the work of the association year of 1916-17 was reviewed. This address is published in full elsewhere in this volume.

This was followed by the annual address of Jesse L. Jones, president of the American Institute of Metals, in which the application of nonferrous metals to war purposes was reviewed and discussed.

The report of the secretary-treasurer of the American Foundrymen's association, A. O. Backert, Cleveland, then was presented as well as the report of the public accountant, Ernst & Ernst, Cleveland, Ohio.

The report of the Board of Directors was presented. This report, which is published in full elsewhere in this volume, contains copies of correspondence between government officials and officers of the association regarding the proposal to send a committee of foundrymen abroad to study the manufacture of hand grenades in French foundries. This suggestion was not acted upon favorably at Washington. Copies of correspondence with the secretary of war regarding an exhibit of war materials at Boston and with the President pledging the services of the association for the vigorous prosecution of the war, also are included in this report. In addition the details of the association's business activities are given in full.

President J. P. Pero announced the appointment of the following convention committees:

Committee on Resolutions:—W. H. McFadden, chairman, Ponca City, Okla.; R. A. Bull, Duquesne Steel Foundry Co., Pittsburgh; Richard Moldenke, Watchung, N. J.; J. F. Kent, American Cast Iron Pipe Co., Birmingham, Ala.; S. Griswold Flagg III, Stanley G. Flagg & Co., Philadelphia; R. F. Har-

rington, Hunt-Spiller Mfg. Corp., Boston; B. D. Fuller, Westinghouse Electric & Mfg. Co., Cleveland.

Nominating Committee:—R. A. Bull, Duquesne Steel Foundry Co., Pittsburgh, chairman; A. W. Walker, Walker & Pratt Mfg. Co., Boston; W. H. McFadden, Ponca City, Okla.; Alfred E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.; Arthur T. Waterfall, Dodge Mfg. Co., Detroit; S. T. Johnston, S. Obermayer Co., Chicago; A. B. Root Jr., Hunt-Spiller Mfg. Corp., Boston; S. Griswold Flagg III, Stanley G. Flagg & Co., Philadelphia.

The following technical paper was presented:

"Fire Prevention in Large Industrial Establishments," by C. W. Johnson, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

General Session

Tuesday, Sept. 25, 10:00 a. m., Paul Revere Hall

R. A. Bull, past president American Foundrymen's association, in the chair. The following papers and reports were presented:

"The Foundry from the Viewpoint of the Sales Engineer," by H. R. Atwater, Osborn Mfg. Co., Cleveland.

"The Relationship of the Engineering Department to the Pattern Shop and Foundry," by F. J. McGrail, Struthers-Wells Co., Warren, Pa.

Report of A. F. A. Committee Advisory to the U. S. Bureau of Standards, by Richard Moldenke, chairman, Watchung, N. J.

"Efficiency in the Foundry," by James A. Fitzgerald, Reno, Pa.

"Co-operative Shop Training," by W. B. Hunter, Fitchburg high school, Fitchburg, Mass.

Report of A. F. A. Committee on Classification of Technical Literature, by Richard Moldenke, Watchung, N. J.

"Facilities for Technical Training at Massachusetts Institute of Technology," by John Ritchie Jr., Massachusetts Institute of Technology, Boston.

The report of the nominating committee was presented at the close of the session on Tuesday. The report was taken under advisement for final action on the following day.

General Session

Wednesday, Sept. 26, 10:00 a. m., Paul Revere Hall

Benj. D. Fuller, vice president of the American Foundrymen's association, in the chair.

The following papers and reports were presented and discussed:

"Improving the Relationship Between Employer and Employe," by J. F. Kent, American Cast Iron Pipe Co., Birmingham, Ala.

Report of A. F. A. Committee on Safety, Sanitation and Fire Prevention, by Victor T. Noonan, chairman, Industrial Commission of Ohio, Columbus, O.

Report of A. F. A. Committee on Foundry Costs, by B. D. Fuller, chairman, Westinghouse Electric & Mfg. Co., Cleveland.

Address on Cost Work of the American Foundrymen's association, by C. E. Knoeppel, C. E. Knoeppel & Co., New York.

Report of A. F. A. Representatives on the Conference Board on Training of Apprentices, by Frank M. Leavitt, chairman, University of Chicago, Chicago.

Report of the A. F. A. Committee on Industrial Education, by Frank M. Leavitt, chairman, University of Chicago, Chicago.

"How Character Analysis Solves the Man Problem," by William Judson Kibby, Cleveland.

"Micro-Metallography for the Foundry," by Robert J. Anderson, Cleveland Metal Products Co., Cleveland.

Considerable discussion developed from the report of the committee on safety, sanitation and fire prevention. After mature consideration it was decided to appoint a joint committee representing the American Foundrymen's association and the National Founders' association to reconsider some features of the safety code, later submitting the revised code to the members of the American Foundrymen's association for adoption

by letter ballot. This has been accomplished and the text of the code as approved appears elsewhere in this volume.

The report of the nominating committee, which had been received at Tuesday's session, was unanimously accepted and the following directors were elected for the year 1917-18: H. R. Atwater, Osborn Mfg. Co., Cleveland; A. O. Backert, Penton Publishing Co., Cleveland; R. A. Bull, Duquesne Steel Foundry Co., Pittsburgh; Henry A. Carpenter, General Fire Extinguisher Co., Providence, R. I.; H. E. Diller, General Electric Co., Erie, Pa.; S. Griswold Flagg III, Stanley G. Flagg & Co., Philadelphia; Benj. D. Fuller, Westinghouse Electric & Mfg. Co., Cleveland; Alfred E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.; C. E. Hoyt, 123 West Madison St., Chicago; W. A. Janssen, Canadian Steel Foundries, Ltd., Montreal, Can.; S. T. Johnston, S. Obermayer Co., Chicago; J. F. Kent, American Cast Iron Pipe Co., Birmingham, Ala.; V. E. Minich, Sand Mixing Machine Co., New York; J. P. Pero, Missouri Malleable Iron Co., East St. Louis, Ill.; Maj. Jos. T. Speer, Pittsburgh Valve Foundry & Construction Co., Pittsburgh; and H. B. Swan, Cadillac Motor Car Co., Detroit.

Gray Iron Session

Thursday, Sept. 27, 10:00 a. m., Paul Revere Hall

A. W. Walker, past president of the American Foundrymen's association, in the chair.

The following papers and reports were read and discussed:

"Note on Fine Molding Sands," by C. P. Karr, U. S. bureau of standards, Washington, D. C.

Report of A. F. A. Committee on General Specifications for Gray Iron Castings, by W. P. Putnam, chairman, Detroit Testing Laboratory, Detroit.

"Briquetting Foundry Borings," by A. L. Stillman, General Briquetting Co., New York.

"Cast Iron Shells in Permanent Molds," by Major Edgar Allen Custer, Philadelphia.

"The Seasoning of Gray Iron Castings," by L. M. Sherwin, Brown & Sharpe Mfg. Co., Providence, R. I.

"Factors in the Economical Production of Small Cores in Large Quantities," by R. E. Kennedy, University of Illinois, Urbana, Ill.

"Modern Centrifugal Cupola Blowers," by J. A. Shorey, General Electric Co., Schenectady, N. Y.

"The Effect of High Sulphur in Gray Iron Castings," by T. Mauland, International Harvester Co., Chicago.

At the conclusion of Thursday's session, a number of important resolutions bearing on the relations of the foundry industry with the government in the present emergency were presented and unanimously adopted by rising votes. R. A. Bull announced that if necessary the association was prepared to spend $10,000 in behalf of the war service board authorized in one of these resolutions. He also said other sums will be raised as needed. In brief, the American Foundrymen's association put itself on record as unreservedly back of the government with all of its financial resources and man-power. The three resolutions are as follows:

War Service Board

Whereas, the foundrymen of America represented in the annual convention now assembled, of the American Foundrymen's association have a strong conviction that the government of the United States can and should receive at the hands of those engaged in the foundry industry in this country, more effective assistance than has hitherto been rendered by foundrymen in the successful prosecution of the war; and

Whereas, the American Foundrymen's association, a national organization of foundrymen engaged in the production of castings, which has a purpose purely technical and educational, has in hand or can obtain from its membership, funds thought to be necessary for the purpose mentioned herein; therefore, be it

Resolved, that the American Foundrymen's association does hereby authorize and direct its president to appoint a war service board to consist of five of the ablest men engaged in the manufacture of gray iron, malleable iron, steel and nonferrous castings in the United States, irrespective of their membership in any organization, who shall serve without compensation and shall give such assistance as a board operating directly, or as a central board governing subsidiary boards or committees, to the government of the United States, as may be possible with the approval of the said government, in the securing of castings of proper quality, at desired rates of production, at fair prices, to meet the needs of said government;

and in the conducting of any investigations into the manufacture of castings considered advisable in the furtherance of the objects mentioned herein; and, be it further

Resolved, that the proper officers of the American Foundrymen's association are hereby authorized, if considered advisable by the said war service board which shall be appointed with the approval of the United States government, to disburse such sums as may be necessary to defray the proper expenses for conducting the work of co-operation with the United States government referred to in the foregoing; and be it further

Resolved, that the directors of the American Foundrymen's association be and they are hereby authorized to take such steps as they may consider advisable to appropriate or secure whatever funds may be needed for the most effective co-operation proposed in these resolutions.

Declaration of the American Foundrymen's Association

Immediately following the declaration of war, your board of directors, by unanimous vote, adopted a resolution extending to the government the support of the foundrymen of America, which was transmitted to the President and received acknowledgment from the nation's executive office. This action was taken because of the impossibility of securing a prompt expression of opinion from our large body of members and because your board was certain that its action expressed the undivided sentiments of every casting manufacturer in the United States.

This association, now in annual convention assembled, not only ratifies the action of the board of directors in the adoption of this resolution, but again pledges every resource of the foundrymen of America to the government in the successful prosecution of this war in order that it may be brought to an early termination.

Therefore, we the members of the American Foundrymen's association, representing the great steel, gray and malleable iron industries of the United States will do all within our power to mobilize our plants and their output, placing them at the disposal of the government and will speed-up production to the end that the needs of our government will be more promptly met and in every other way we promise our aid and support to our country to hasten the defeat of our enemies.

Liberty Loan

Whereas, The members of the American Foundrymen's association realize that for the prosecution of the war large sums of money are needed, making necessary the sale of government bonds in addition to the sums raised by taxation, and whereas another issue of Liberty bonds is about to be made, therefore

Be It Resolved, that the members of the American Foundrymen's association devote the same efforts to the sale of the second and succeeding issues as they so patriotically devoted to the first bond issue, and

Be It Further Resolved, that the employing members of this association render every possible assistance to their employes in the purchase of bonds.

Malleable Session

Wednesday, Sept. 26, Mechanics' Building, Talbot Hall

J. P. Pero, president of the American Foundrymen's association, in the chair. The following papers were read and discussed:

"The Theory of the Modern Waste-Heat Boiler and Possible Application of Such Boilers to the Malleable Melting Furnace," by A. D. Pratt, Babcock & Wilcox Co., New York.

"Application of Waste-Heat Boilers to the Malleable Melting Furnace," by C. D. Townsend, Danville Malleable Iron Co., Danville, Ill.

"Application of Pulverized Coal to the Air Furnace," by W. R. Bean, Naugatuck Malleable Iron Works, Naugatuck, Conn.

"The Application of Pulverized Coal to Malleable Melting Furnaces," by Joseph Harrington, Chicago.

"How Malleable Iron Has Improved," by Enrique Touceda, Albany, N. Y.

"Troubles Encountered in Machining Malleable Iron: Causes and Remedies," by A. T. Jeffery, Dayton Malleable Iron Co., Dayton, O.

"Comparative Carbon Losses in Malleable Iron Annealing by Muffle and Pot Oven Methods," by Joseph B. Deisher, T. H. Symington Co., Rochester, N. Y.

"The Effect of Iron Oxide in Molding Sand," by W. R. Bean, Naugatuck Malleable Iron Works, Naugatuck, Conn.

Steel Session

Thursday, Sept. 27, 10:00 a. m., Paul Revere Hall

A. H. Jameson in the chair.

The following papers and reports were read and discussed:

"Molding and Casting Large Slag Pots," by C. J. McMahon, Illinois Steel Co., Chicago.

"A Description of a Small Open-Hearth Furnace," by David McLain, McLain's System, Milwaukee.

"A New System of Burning Crude Oil," by W. A. Janssen, Davenport, Ia.

"The Use of Vanadium in Steel Castings," by J. Lloyd Uhler, Union Steel Castings Co., Pittsburgh.

Report of A. F. A. Committee on Steel Foundry Standards, by W. A. Janssen, chairman, Davenport, Ia.

Steel Session

Friday, Sept. 28, 10:00 a. m., Talbot Hall

W. A. Janssen, member of the board of directors of the American Foundrymen's association, in the chair.

The following papers were read and discussed:

"Notes on An Electric Furnace Design," by John A. Crowley, John A. Crowley Co., Detroit.

"Recent Developments in the Application of the Electric Furnace to the Melting Problem," by Douglas Walker, Booth-Hall Co., Chicago.

"Comparison of Electric Furnace and Steel Converter for the Manufacture of Small Steel Castings," by C. R. Messinger, Sivyer Steel Casting Co., Milwaukee.

"The Electric Furnace from the Central Station Standpoint," by E. L. Crosby, Detroit Edison Co., Detroit.

Final Professional and Business Session

Friday, Sept. 28, 10:00 a. m., Paul Revere Hall

J. P. Pero, president of the American Foundrymen's association, in the chair.

The following papers were read and discussed:

"Solution of Foundry Transportation and Conveying Problems," by Robert E. Newcomb, Deane Works, Worthington Pump & Machinery Corp., Holyoke, Mass.

"Sand-Blasting in the Foundry," by H. L. Wadsworth, American Foundry Equipment Co., Cleveland.

"Experiments to Determine the Most Effective Means of Mixing and Blending Foundry Facing Sands," by R. F. Harrington, Hunt-Spiller Mfg. Corp., Boston.

"Oxy-Acetylene Welding and Cutting," by Stuart Plumley, Davis-Bournonville Co., Boston.

"Factors Contributing to the Economical Use of Grinding Wheels in the Foundry," by Wallace T. Montague, Norton Co., Worcester, Mass.

"Refractory Materials Employed in the Metallurgical Industries," by H. C. Arnold, University of Illinois, Urbana, Ill.

"Steel Castings for Ordnance Construction," by Major C. M. Wesson, Watertown Arsenal, Watertown, Mass.

Announcement was made of the election of officers of the American Foundrymen's association to serve for the ensuing year, as follows:

President.—Benj. D. Fuller, Westinghouse Electric & Mfg. Co., Cleveland.

Vice President.—S. Griswold Flagg III, Stanley G. Flagg & Co., Philadelphia.

Secretary-Treasurer.—A. O. Backert, Penton Publishing Co., Cleveland.

The following resolutions of thanks, prepared by the committee on resolutions, was presented and unanimously adopted:

Whereas, this convention of the American Foundrymen's association is one of the most successful in its history, and

Whereas, this is attributable in a very great measure to those who have toiled unceasingly in the reception and entertainment of the large number of visitors in attendance, and

Whereas, the technical program was unparalleled in number and excellence of papers on a variety of subjects of interest to gray and malleable iron and steel foundrymen; therefore, be it

Resolved, that the members of the American Foundrymen's association extend their deep appreciation and hearty thanks to the New England Foundrymen's association and the members of the committees of that organization, who have made our visit to Boston so enjoyable and whose hospitality was without bounds; to the city of Boston and its chief executive, Hon. James M. Curley; to the Boston chamber of commerce; to the management of Mechanics building; to the authors who contributed to our program; to the daily press of Boston, the trade press of the country, the hotels, etc., that in any way contributed to the wonderful success of this, the twenty-second annual meeting of our organization.

The secretary was directed to have a copy of this resolu-

tion suitably engrossed and delivered to the New England Foundrymen's association.

Upon motion of R. A. Bull, the retiring president, J. P. Pero, was unanimously elected an honorary member of the American Foundrymen's association.

Following the installation of the newly elected officers of the American Foundrymen's association, the proceedings of the twenty-second annual convention were unanimously approved.

There being no further business, the meeting was adjourned.

Annual Banquet

Thursday, Sept. 27, 7:00 p. m., Copley Plaza Hotel

Alfred E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn., presided.

The following addresses were delivered: "Dollars and Sense," by Judge Chas. F. Moore, New York, and "The Achievements of France," by John A. Penton, president, The Penton Publishing Co., Cleveland.

Entertainment Features

The one-session-per-day arrangement allowed the visiting foundrymen and their friends freedom to enjoy the entertainment features planned by the local committee of the New England Foundrymen's association. On Tuesday afternoon, several hundred members of the association participated in a boat ride on the steamer *Rose Standish* in and about Boston harbor. Tickets were furnished to the American League ball game between Boston and Cleveland on Wednesday afternoon, Sept. 26. Free tickets also were furnished for a theater party at B. F. Keith's theater, Wednesday evening. Thursday a luncheon was held for the visiting ladies followed by an automobile ride to various points of interest around Boston.

Plant visitation was a conspicuous feature of the meeting and many foundries in Boston and vicinity were open for inspection. A special trip was made to the Lynn plant of the General Electric Co. on Thursday, Sept. 27.

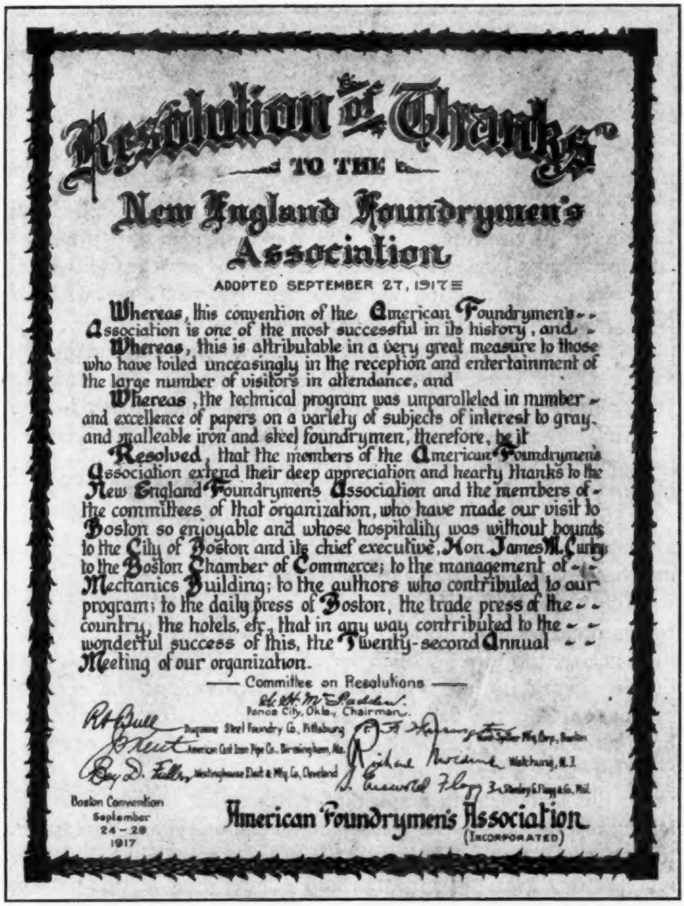
Remarks of Toastmaster, Mr. Alfred E. Howell, at Banquet

It would be a pleasure to revert to the many historical memories which Boston revives, not the least, that she was "The Cradle of Liberty" in the new world. I am reminded of the words of Baron Turgot, the great French statesman, who, while Franklin was in Paris, and when Lafayette and Rochambeau came to the relief of George Washington and the American colonies 130 years ago, said:

"The shelter which America is going to offer to the oppressed of all nations will console the earth. It is impossible not to form wishes for the American people to reach the utmost prosperity it is capable of. That people is the hope of mankind. It must show to the world by its example, that men can be free and tranquil, and can do without the chains that tyrants and cheats of all garb, have tried to lay on them under pretense of public good. It must give the example of political liberty, religious liberty, commercial and industrial liberty to the world."

France's aid to us was not for recompense, but for liberty alone. Now, after these 130 years, it is our turn to help France, and all of Europe for that matter, to regain that equilibrium that is so altered in the world. Truly, America is become, indeed, "The Hope of Mankind."

I cannot refrain from reiterating the expressions I have heard all week on all sides, of the pleasure of finding ourselves in Boston, after 15 years. In that time, not only has our association made vast strides, but the New England Foundrymen's association has kept step with the progress of this wonderful city of Boston. The hospitality of our hosts has been on a scale, and of a quality, that has made an indelible imprint on our minds and hearts, and to our hosts we acknowledge our most grateful appreciation.



Resolution of Thanks

TO THE

New England Foundrymen's Association

ADOPTED SEPTEMBER 27, 1917

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Whereas, the technical program was unparalleled in number and excellence of papers on a variety of subjects of interest to gray, and malleable iron and steel foundrymen, therefore, be it

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— Committee on Resolutions —

Ponca City, Okla., Chairman.

Duquesne Steel Foundry Co., Pittsburg

American Cast Iron Pipe Co., Birmingham, Ala.

Westinghouse Elect. & Mfg. Co., Cleveland

Watchung, N.J.

Boston Convention
September
24 – 28
1917

American Foundrymen's Association
(Incorporated)

ENGROSSED RESOLUTION OF THANKS PRESENTED TO NEW ENGLAND FOUNDRYMEN'S ASSOCIATION

Annual Address

By the President, J. P. Pero

I am sure you will pardon the pride I feel as a New Englander in presiding over this convention in the principal city of New England—Boston—the Hub of the Universe. Previous to this meeting we have held but one convention in New England, at Boston, in 1902, fifteen years ago. As a matter of history, perhaps not generally known, particularly by some of our younger members, let me remind you that 15 years before the Boston convention, and nine years before the first convention of the American Foundrymen's association, the New England Foundry Foremen's association was organized in Springfield, Mass., in 1887.

That, as far as I have been able to learn, was the first association of this kind ever organized. It numbered in its membership the leading foundry foremen of that period in New England, some of whom are here today, while others are represented by their descendants. It was my good fortune to conceive the idea of such an association, perform the preliminary work for the first meeting and preside at the opening session of that, the first association organized for the purpose of interchange of views and experiences in foundry practice, and for the general uplift of the foundry trade. I do not make this statement in a spirit of egotism, but merely to relate an interesting fact in the history of the industry, and to explain to you the pleasure and pride I feel in occupying the highest office in this great organization and in presiding at this session on the thirtieth anniversary of the organization of the first educational association of foundrymen.

As my term of office as president of this great association draws to a close, it is but right that I should furnish you a short resume of the work of the association during the past year and give expression to some views as to the future of the

association—but in presenting this resume and these views, I do not intend in any manner to detract from nor to anticipate the reports of the committees, nor to define the work of succeeding officers of the association.

I would be an ingrate, did I not feel a just pride in having been selected as your president and would be still more ungrateful did I not give credit to my associates on the executive board, as well as to the various committees whose work has been so well done. In addition, I want to express my deepest appreciation of the kindly co-operation of our famous old war-horses, Daddy Seaman, Major Speer and the other past presidents of the association.

I feel especially indebted to our secretary-treasurer, A. O. Backert, whose ability is equalled only by his interest and willingness to serve in any manner, to produce the best results for the association.

A New Policy

Last year at Cleveland we inaugurated a new policy, by incorporating the association and taking upon ourselves the management of the exhibition feature of the convention. It is unnecessary to rehearse here the many causes leading up to, and finally culminating in the Cleveland exhibition being held under our auspices. Those of you who visited the exhibition last year were proud of the success of the undertaking, and I believe that if further evidence is necessary to establish the wisdom of the policy of making the exhibition an essential feature of our annual convention, and under our own management, that evidence will be found in the exhibition at Mechanics building this week.

It is but fair to attribute the success of the exhibition to the loyalty and business foresight of the exhibitors, and to the ability and untiring efforts of our exhibition manager, C. E. Hoyt, and it is a pleasure to express to them my sincere thanks for their co-operation.

As foundrymen, we point with pride to the wonderful progress made in foundry practice in the past 25 years, and as members of the American Foundrymen's association we are justly proud of the prominent part our society has played in

contributing to the present state of excellence. We have accomplished much, but we have only begun. I believe we have reached only the threshold of progress; the door is open for still greater improvement, and I predict that those of you who attend our sessions 25 years hence will marvel at the gigantic strides made during that period, even as we now in retrospect wonder at the progress already made.

As we attend the various sessions the coming week, we will realize the efficient work done by the committee on papers, under the direction of H. Cole Estep of Cleveland. To this committee, and to those who during the past year in the most strenuous times ever known in the foundry industry, have added to their trying duties the task of furnishing so excellent a program, I extend my personal thanks and the thanks of the association.

Welfare Work

In these enlightened times the questions of the health, safety and comfort of employes are receiving much consideration both from humanitarian and commercial standpoints. Our association is in the vanguard in this work. Foundrymen, in common with leaders in every industry, have awakened to the realization of the enormous and unnecessary losses caused by fires. Our committee on safety, sanitation and fire prevention has devoted much thought, time and effort to this important work, and its report will recommend a safety code for adoption by the association. You will readily realize, in looking over the personnel of the committee, under the leadership of Victor T. Noonan of the Industrial Commission of the State of Ohio, that these men, trained and experienced in the commendable work of conservation of life and limb, as well as the elimination of fire losses, constitute a remarkably capable body, for the most intelligent consideration of these important matters, and I bespeak for their report your earnest consideration and support, and I extend them our sincere thanks for valuable work done.

One of the supposedly important features of progress during the past 25 years in the foundry, as well as in other industries, is specialization. But specialization, like many other

seemingly good things, has its limitations, and we are at last beginning to realize that specialists are not thorough mechanics. As a consequence, we now face a problem of the utmost importance. It matters not to us whether the present condition has been brought upon us by the desire of the employer for increased production or decreased cost, or both, or whether the attitude of the labor unions in restricting the number of apprentices is responsible for existing conditions. This we know, that unless steps are taken to make the foundry industry more attractive to our young men, and an efficient system of training and indenturing of apprentices is adopted, we will have very few capable, all-around molders in the next generation.

The Writing on the Wall

The American Foundrymen's association has seen the writing on the wall and numbers among its committees one which represents the association on the Conference Board on Training of Apprentices. This committee, with F. M. Leavitt of the University of Chicago as chairman, consists of men who have made a life study of the apprentice question from both the technical and practical points of view and each member occupies a position of responsibility in this line of work with some of the leading institutions of the country. As different geographical sections of the country are represented in the membership of the committee, we may be assured of gratifying results from its work, which has entailed many sacrifices of time and thought by its members. I heartily thank them in the name of the association for their valuable assistance.

I would be glad, in justice to the different committees, and as a mark of appreciation of their work, to embody in this address mention of the importance and excellence of the work they have performed. I realize, however, that such a procedure is unnecessary, as the reports of the committees on the practical and the technical problems of the foundry industry will be so ably presented during the sessions as to fully demonstrate their efficient work. I therefore prefer to confine my remarks concerning committees to those whose work is comparatively new to us, and is related more closely to the commercial side of the industry than to the technical side.

Since our meeting in Cleveland, our country has been drawn into the world war. Immediately before the declaration of war by our government, Past President Bull and I collaborated in drafting resolutions, pledging the support of the American Foundrymen's association to the President and government of the United States. Copies were sent to our directors for their approval. Their response by wire was prompt, emphatic and unanimous, and resulted in the following letter and resolutions being forwarded to President Wilson:

East St. Louis, Ill., March 31, 1917.

Woodrow Wilson,
Washington, D. C.

Your Excellency:

It affords me great pleasure to enclose a copy of resolutions adopted by the directors of the American Foundrymen's association, which I am instructed to forward to you.

The American Foundrymen's association is a purely educational organization, and its membership of over 1000 represents the ablest and most progressive men in the foundry industry.

Both the leading political parties are represented in our directorate, but their action as shown by these resolutions, is that of American citizens, sending to the President of their country, words of encouragement, and assuring him of their unqualified support in his official acts.

Sincerely praying that the God of nations will direct and sustain you, we are,

Yours very truly,
American Foundrymen's Association.

RESOLUTIONS

Whereas, At this crisis in our nation's affairs, it is the solemn duty of all Americans to show their zealous loyalty to the government, and

Whereas, Organizations whose purposes are vitally connected with the industrial progress of our country, may by their official action, be the convenient spokesmen for their members, therefore,

Be it resolved, By the directors of the American Foundrymen's association, that the President of the United States be assured of the earnest support of the foundrymen of America, in the most vigorous and unswerving defense of our nation's rights and honor against the attacks of any foreign country.

That the said directors believe that the thousand members whom they represent are universally and individually willing to make whatever sacrifices may reasonably be asked

of them in active support of the government's requirements, whatever they may be.

That the said directors feel that universal and compulsory training is indispensable to our nation's security.

That the present crisis justified this association in breaking a precedent which has heretofore confined its expressions to matters of purely technical or educational character, and,

That the officers of the American Foundrymen's association be directed to transmit to the President of the United States a copy of these resolutions.

This communication was promptly answered, as follows:

The White House, Washington.

The President thanks you cordially for the good will which prompted your kind message, which has helped to reassure him and keep him in heart.

On April 28, I wrote Howard E. Coffin, advisory board of national defense at Washington, calling his attention to the probable demands to be made upon the foundry industry for the manufacture of munitions and equipment for the prosecution of the war and proposing to send at the expense of the American Foundrymen's association, and with the sanction of the government, a commission of three foundrymen to France to study methods of the manufacture of these materials, also calling his attention to our exhibition as a medium of demonstrating the details of their manufacture. Mr. Coffin referred our letter to the munitions board, and heartily thanked the association for the offer of co-operation. This resulted in correspondence with the war department, and with Mr. Coffin, who expressed his appreciation of our offer of co-operation, advising us that our communications would be filed for future reference, should occasion arise to utilize our services. This correspondence appears in the report of the board of directors and bears evidence of the fact that our association immediately upon the declaration of war by President Wilson, promptly tendered him and the government our unqualified and fullest support, and while as an association we have not yet been called upon to assist the government in connection with the present war, we still hold ourselves in readiness to serve, actuated only by the highest motives of patriotism, and the desire to do our bit, and more to support our government in the preservation

of the honor and integrity of this great country of ours, and to keep unsullied the dear old Stars and Stripes.

Nor does our duty end here. As an association we can do much toward the successful conduct of the war. As individuals we can do more. There must not be any slackers among us. It is time for action. With a certainty of depletion among our workmen, caused by enlistment and conscription, contemporaneous with an increased demand for our products, there must be a general speeding up. Just how this is to be accomplished is one of the problems we are now facing, a weighty problem demanding immediate solution. Knowing the personnel of the American Foundrymen's association as I know it, I feel justified in predicting a prompt and successful solution.

Committee on Foundry Costs

I earnestly appeal for your support on behalf of the committee on foundry costs. Probably there is no branch of manufacturing industry in which so little is known of actual cost of production as in the foundry. Volumes might be written of the demoralizing effect upon the industry of this very general ignorance of cost of production. Our committee on foundry costs has completed arrangements with a well-known firm of accountants to install simple, practical and efficient cost systems in the plants of the members of the American Foundrymen's association who wish to become subscribers to the foundry cost movement, the details of which have been sent to the members of the association. It is gratifying to the association and to the committee, of which Vice President Benjamin D. Fuller is chairman, to report 102 subscribers to this system, and a total subscription of over $7000. This is one of the important undertakings of the association. The committee has worked earnestly and intelligently to secure for foundrymen a reliable method of ascertaining cost of production. The report will show that the gentlemen on this committee have succeeded admirably and are entitled to our thanks and our support.

Our relations with kindred organizations have been and are most pleasant and agreeable. Our esteemed neighbor, the American Institute of Metals, is holding its convention in

Boston, simultaneously with ours, as heretofore. We hope for a continuance of pleasant relations with all technical associations.

Much is being written and said at this time of war profits. I cannot conceive of the possibility of abnormal profits under present conditions of increased cost of material and labor. There may have been large war profits distributed among a few before the United States went into the war; there certainly were losses, too, many during that period. But I have so strong a faith in the loyalty and patriotism of the members of the American Foundrymen's association that I have no hesitancy in affirming that the foundrymen of this great country are above taking advantage of its needs, and that their chief desire is to see an honorable and lasting peace restored to a world undergoing the throes of a cataclysm such as never before has been known in history.

In the rehabilitation of Europe, we are destined to play an important part, and in my judgment the problems we now face in the conduct of this war are but preparation for greater problems in the future. We may rest assured that American skill and energy will successfully cope with any conditions which may arise, and that when the time comes, the American Foundrymen's association will be found in the vanguard ably performing its share in the stupendous work.

I cannot close without again thanking you gentlemen for the honor conferred upon me in selecting me as your chief officer during the past year, and I wish to express my sincere appreciation for the hearty co-operation and support so cheerfully given me by all my associates. I sincerely hope the association may derive as much benefit from my efforts as I have derived from the pleasure of serving you.

Annual Report of the Board of Directors

To the Members of the American Foundrymen's Association, Incorporated:—

During the past year three meetings of the Board of Directors of the American Foundrymen's Association, Incorporated, were held. The first meeting, at the Statler hotel, Cleveland, Sept. 13, 1916, was preceded by the final session of the Executive Board of the American Foundrymen's association, not incorporated, held at the Hollenden hotel, Cleveland, Sept. 11, 1916. At the annual convention, held at Cleveland last year, it was unanimously decided to take over the affairs, property, etc., of the American Foundrymen's association, unincorporated, by the American Foundrymen's association, Incorporated, and the Executive Board of the American Foundrymen's association was succeeded by the Board of Directors of the American Foundrymen's Association, Incorporated. This board consists of 16 members, and appreciating the difficulty of insuring their attendance at meetings, owing to their widely scattered locations throughout the country, it was decided to appoint an Executive Committee of the Board of Directors. This committee held two meetings during the year, one at the Hotel Anderson, Pittsburgh, Dec. 17, 1916, and the other at the Hotel La Salle, Chicago, Jan. 28, 1917. The Board of Directors of the American Foundrymen's Association, Incorporated, held three meetings, as follows: Sept. 13 and 14, 1916, Statler hotel, Cleveland, and June 17, 1917, at the Hotel Anderson, Pittsburgh. Also, two meetings of the Exhibition Committee of your association were held, at the Hotel La Salle, Chicago, Jan. 28, 1917, and at the Hotel Anderson, Pittsburgh, June 17, 1917.

The last meeting of the Board of Directors, held at the Hotel Anderson, Pittsburgh, June 17, 1917, was called for the purpose of discussing the advisability of sending a commission representing the American Foundrymen's Association, Incorporated, to France and England for the purpose of investigating

the manufacture of cast iron shells and hand grenades. On April 28, 1917, your president, J. P. Pero, addressed the following communication to Howard E. Coffin of the Advisory Board of National Defense, Washington, D. C.:

East St. Louis, Ill., April 28, 1917.

Howard E. Coffin,
Advisory Commission of the Council of National Defense,
Washington, D. C.

Dear Sir:—

The writer noted in the April issue of *The Foundry*, a technical magazine devoted to foundry interests, an article on the making of cast iron shrapnel in France, and the thought has occurred to him that there is at least a possibility of our country finding it necessary to take up this line of work. As our foundrymen have had little, if any experience along these lines, it would seem to me that perhaps it would be policy on the part of your Board to send to France a commission of perhaps three foundrymen of national reputation to investigate the methods of producing these castings and learn from the experience of France.

This plan undoubtedly would result in a saving of time and of money, if we in this country found it necessary to go into this line of work.

As President of the American Foundrymen's association, I am glad to offer to you the co-operation of the association, not alone in this matter, but in any problem connected with the foundry business which your Board has to face.

Our organization is composed of about 1000 of the ablest men, both technical and practical, in the foundry industry of America and is purely a technical and educational organization.

I am making this explanation in order that you can see that we are rendering you the services of a powerful organization, in both technical and practical foundry problems.

I also would call your attention to the fact that we hold our annual convention in Boston, Mass., during the week of Sept. 24, and in connection with our technical sessions we have an exhibition of foundry devices and appliances which, this year, will be held in Mechanics' building at Boston. Four days of the convention are devoted to technical sessions, held simultaneously by the gray iron, steel, malleable and brass sections, the last of which is held under the auspices of the American Institute of Metals.

Since the declaration of war, the Directors of our Association have given the matter of co-operation with the Government considerable study, and among other means of co-operation it has been suggested that the Government might take advantage of our exhibition by sending samples of their requirements in the munitions line, including gray iron, steel and brass to the proper authorities, and if this looks expedient to the proper authorities and if they will give us sufficient time we will gladly provide the exhibition space and give the matter sufficient publicity to insure not only the interest of the foundrymen of the country, but of the manufacturers of machinery for producing all such materials as are required; in fact, we will make our exhibition a clearing house, in

which the producers and consumers of this material may get together in the most satisfactory manner.

I trust you will give this lengthy letter serious consideration. We have no axe to grind and are merely striving to co-operate with you in supporting the Government in this trying time.

Awaiting your reply with interest, we are,

Yours very truly,

AMERICAN FOUNDRYMEN'S ASSOCIATION, INC.,
J. P. PERO, President.

On May 5, 1917, the following reply was received by Mr. Pero from Howard E. Coffin:

ADVISORY COMMISSION
Of the
COUNCIL OF NATIONAL DEFENSE

Washington, D. C., May 5, 1917.

J. P. Pero, President,
American Foundrymen's Association,
East St. Louis, Ill.

My Dear Sir:

I beg to acknowledge your letter of April 28, regarding the making of cast iron shrapnel. I am taking the liberty of referring this letter to the office of the Munitions Board, who are in close touch with these matters.

Plans are being considered for sending of Commissions to France and England, but for the present the make-up of these Commissions is being held up by pressure of work in this country.

Please accept my thanks for the offer of co-operation of your association, which is much appreciated.

Yours very truly,
H. E. COFFIN.

On May 16, 1917, your president replied as follows to the communication from Mr. Coffin:

East St. Louis, Ill., May 16, 1917.

Mr. H. E. Coffin,
Advisory Commission of the Council of National Defense,
Washington, D. C.

Dear Sir:

You will pardon my delay in acknowledging receipt of yours of the 5th.

I wish to thank you for referring my letter to the Munitions Board, but at this writing I have heard nothing from its members.

Perhaps I did not make myself clear in the previous letter with reference to the sending of a commission to Europe. It is the intention of the American Foundrymen's association to bear the expense of the Commission if the Government sanctions such a move, and we further believe we can relieve your commission of the Munitions Board of any worry and care in the matter of naming the commission. This is not a political move on our part, but we feel that we are in position to select the men best fitted for this work, on account of our thorough acquaintance with the leading foundrymen of the country, and if the proper Government authori-

ties would sanction our proposal, we will confer with them and will assume all expense, as well as the naming of the commission, simply reporting to the Munitions Board our findings, although, of course, we will be open to suggestions and advice from the Board.

We believe that in a short conference with the proper authorities, we can make satisfactory arrangements to carry out their plans and do it promptly and well.

Thanking you very much for the interest shown, we are

Yours truly,

J. P. Pero, President.

Subsequently, your secretary likewise communicated with Howard E. Coffin, chairman of the Advisory Commission of the Council of National Defense and on June 14 he was notified that the ordnance experts of the United States Government did not think it probable that cast iron could be used advantageously in the manufacture of shrapnel. Continuing, he stated that if these shells had been used, it has been from necessity and not from choice. The concluding paragraph of this communication follows:

If any members of your association desire to visit Europe for the purpose mentioned this would have to be done in their private capacity since it is not practicable at this time at least to arrange for any official visit to Europe for this purpose.

This communication finally disposes of the possibility of sending a commission to France this year, for the purpose outlined.

Your president also endeavored to enlist the interest of the Government in making a munitions exhibit at Boston and in a communication addressed to Hon. Newton D. Baker, secretary of war, dated May 10, 1917, he offered the hearty co-operation of the members of your association to the government in the manufacture of munitions. This letter follows:

East St. Louis, Ill., May 10, 1917.

Hon. Newton D. Baker,
Secretary of War,
Washington, D. C.

Dear Sir:

You will perhaps recall having sat beside the writer at the banquet given by the American Foundrymen's association during their convention in Cleveland last September.

I am recalling this occasion to you merely for the purpose of identifying myself and giving to this letter a little personality.

As president of the American Foundrymen's association, I recently wrote Mr. H. E. Coffin, tendering to him the co-operation of the association in connection with the work of the government

during this trying period. I have recently received a reply from Mr. Coffin, advising me that he had referred my communication to the Munitions Commission.

In recent correspondence with Mr. A. O. Backert of Cleveland, secretary of our association, we have agreed that it would be wise to write you, offering you and through you, our Government, our hearty co-operation in everything pertaining to the making of castings in either gray iron, malleable iron or steel, which the Government may require.

As you undoubtedly are aware, the American Foundrymen's association, through its one thousand members, represents the ablest and most progressive men in the foundry industry, both in the United States and Canada, and for this reason it would seem that the association would be the logical source to which the Government should apply for assistance in the solution of any problem relating to castings which may arise.

We, as an association and individually, tender the Government any assistance we may be called upon to furnish. In connection with munitions, we would like to suggest that at our convention in Boston in September we will, as is our custom, have an exhibition of foundry appliances, the exhibition to be held in Mechanics' building. The exhibitors consist of practically every manufacturer and dealer in foundry appliances and supplies in this country.

It has occurred to us that it might be to the advantage of the Government to send to our exhibition a complete line of the munitions required during the war, and if the Government is disposed to act upon this proposition, we will gladly donate all necessary space at no expense whatever to the Government.

If this suggestion meets with your approval, we will give the intended exhibit all possible publicity, with a view not only to interest the various foundrymen in the manufacture of the castings, but also to interest the manufacturer of various tools and machinery required for finishing the rough castings. In short, we offer the Government the use of our exhibition as a clearing house in which everybody connected with the manufacture of munitions may conveniently get together for a more complete acquaintance with the problems connected with the manufacture of munitions, and, as stated, we are glad to offer the Government this opportunity at no expense whatever. We will be glad to have you give this matter consideration at your convenience, and if it appeals to you favorably, we would like to hear from you further.

We wish to assure you that we are willing and ready to do all in our power to further the best interests of the United States.

We might further add that in connection with our convention in Boston, the American Institute of Metals holds its annual meeting. Its membership is confined entirely to the workers in brass and bronze, while our organization is confined to workers in gray iron, malleable and steel. Our exhibition, however, covers their line of work as fully as it does our own.

This letter may be rather lengthy, but I will apologize for it by saying to you that I have tried to make our position and our facilities plain to you.

Awaiting with interest your reply and with very kind personal regards, I am,

Yours very truly,

J. P. Pero, President.

A reply, dated May 22, 1917, was received from the war department, signed by I. W. Littel, Colonel, Quartermaster Corps, in charge of cantonment construction, which is reproduced herewith:

WAR DEPARTMENT

Washington, D. C., May 22, 1917.

J. P. Pero, President,
American Foundrymen's Association,
East St. Louis, Ill.

Dear Sir:

This office is in receipt of your letter of May 10, addressed to the Secretary of War, offering the services of the American Foundrymen's association in whatever capacity they may be considered most desirable. This generous offer is appreciated and your communication will be preserved for future reference should occasion arise to utilize such services.

By authority of the Secretary of War,

I. W. LITTEL,

Colonel, Quartermaster Corps, in charge of Cantonment Construction.

On May 12, 1917, your secretary also addressed the following communication to Hon. Newton D. Baker, secretary of war, in an effort to enlist his interest in making a munitions exhibit at Boston:

Cleveland, Ohio, May 12, 1917.

Hon. Newton D. Baker,
Secretary of War,
Washington, D. C.

My Dear Mr. Secretary:

All of the members of our association still have pleasant recollections of your magnificent address delivered at our banquet at the Hotel Statler and at that time we believe you had an opportunity, at least in a cursory manner, of judging the nature of our organization from the audience in attendance.

Our next annual meeting and exhibition of foundry equipment, machine tools, accessories, etc., will be held in Boston during the week of Sept. 24. From present indications this will be the greatest event of its kind in the history of our organization. Nothwithstanding the temporary lull in business conditions resulting from the war, a greater number of manufacturers have made reservations for exhibit space than were received up to June 1 last year and this gives us assurance of the greatest exhibition of this kind ever held in the country. Spacious Mechanics' hall has been leased for this purpose, approximately 80,000 square feet of floor space being available for exhibition purposes. This exhibition is going to be a great patriotic demonstration of the preparedness of the foundry and machine tool industries of the United States to serve their country in its present crisis.

In this connection we desire to enlist the interest of the army and navy departments in making an exhibit of munitions of war,

castings and other parts produced by foundries and machine shops and free space will be allotted to the Government for this purpose. If possible, we would like to have Government representatives in attendance, preferably engineers well versed in the requirements of the Army and Navy requirements, who could impart to the visiting foundrymen and machine shop operators information regarding specifications, methods of manufacture, etc., of munitions of war. Also, we are wondering whether engineers from England and France will be in this country at that time and if so, we will be glad to have them take part in a similar manner outlined for our Army and Navy engineers. We appreciate that this is an unusual suggestion, nevertheless, we do feel that the great army of foundrymen and machine shop operators of the United States and Canada would receive wonderful instruction from an exhibit of this kind, to say nothing of the added information that could be obtained from the engineers in charge.

If this does not properly fall within your province we would be pleased to have you forward it to the proper Government officials or departments, since we are anxious to do everything in our power to render every possible aid.

The writer had the pleasure of greeting you in this city on Monday night on the Pennsylvania station platform at East 55th St., but he hesitated to lay this matter before you on the train since he did not desire to intrude on your privacy.

Assuring you that your acceptance of free space for an exhibit of this kind will be greatly appreciated by the members of the American Foundrymen's association and the American Institute of Metals, we remain,

Respectfully yours,
AMERICAN FOUNDRYMEN'S ASSOCIATION, INC.,
A. O. BACKERT, Secretary-Treasurer.

The foregoing was acknowledged as follows, on May 23, by the secretary of war:

WAR DEPARTMENT
WASHINGTON

May 23, 1917.

My Dear Mr. Backert:

Immediately upon receipt of your letter of May 12, I referred the matter to the Chief of Ordnance to determine whether it would be possible for us to have an exhibition such as you desire at the next annual meeting of the American Foundrymen's association. I regret to find it impossible, but I enclose you a memorandum from General Crozier which will explain the situation.

Cordially yours,
Newton D. Baker, Secretary of War.

The memorandum from General Crozier, referred to by Secretary of War Baker, follows:

WAR DEPARTMENT
OFFICE OF THE CHIEF OF ORDNANCE
WASHINGTON

May 19, 1917.

Memorandum for the Secretary of War:

SUBJECT:—Request for government exhibit at American Foundrymen's Association.

Under normal conditions an exhibition of Army and Navy material, especially as part of the exhibit of the American Foundrymen's association, would be a matter of considerable note and of possible advantage to the Federal Government. The preparation of such an exhibit, however, involves considerable time and the attention of a trained officer. At present the demands upon the personnel of the Ordnance Department are so far in excess of its ability to properly meet the situation and no one can be assigned for the purpose outlined in the accompanying communication, without neglecting other, and undoubtedly much more important, matters.

William Crozier,
Brig. Gen., Chief of Ordnance, U. S. A.

On May 28 your secretary again addressed Hon. Newton D. Baker in an effort to insure this exhibit, by extending the co-operation of the association to insure this display. This letter follows:

Hon. Newton D. Baker,
Secretary of War,
Washington, D. C.

My Dear Mr. Baker:

It is with a feeling of keen regret, of course, that the War Department finds it impossible to co-operate with us in making an exhibit of munitions, as outlined in our previous communication, but we can readily understand how hard pressed your department is for the service of trained officers at the present time. We are wondering however, whether there is not a possibility of further co-operation on our part to insure this exhibit, since we feel certain that among our large membership there must be some member highly trained in ordnance work, who might co-operate with you and relieve you of the necessity of having a trained officer in charge of this exhibit. We feel positive that this is a matter of great importance to our members and to the Government and for this reason we hesitate to let it pass.

The writer was privileged to attend the meeting of the editors of the trade press at Washington last Friday, and as usual, was charmed and greatly pleased with your remarks. The meeting certainly impressed us with the earnestness of our Government officials in this great crisis and the one feature to be deeply deplored is the fact that our country is not fully alive to the situation and to the tremendous task we have before us.

Thanking you for the interest you have shown and assuring you of our willingness to help in every possible way, we remain,

Sincerely yours,
AMERICAN FOUNDRYMEN'S ASSOCIATION.
A. O. Backert, Secretary-Treasurer.

On May 30, 1917, this subject was finally closed by the following communication which was received from the Secretary of War:

WAR DEPARTMENT
WASHINGTON

May 30, 1917.

My dear Mr. Backert:

I have just received your letter of the 28th. I regret to insist upon my previous decision, but I know just how absorbed all the energies of the Ordnance Department are at this time, and how vitally necessary it is that they should not turn aside even for anything so useful as the exhibit would be. I think we had better give up all hope of having it this year.

Cordially yours,

NEWTON D. BAKER, Secretary of War.

Following the declaration of war, your president in collaboration with Past President R. A. Bull, prepared resolutions pledging the support of our organization to the Government, copies of which were sent to the members of the Board for their approval. Their reply by wire was prompt, emphatic and unanimous and these resolutions accompanied by a letter were sent to President Wilson and were promptly acknowledged.

At the meeting of the Exhibition Committee of the American Foundrymen's Association, Incorporated, held at the Anderson hotel, Pittsburgh, Dec. 16, 1916, the report of the manager of your exhibition department was submitted and appears elsewhere. It showed a final profit of $6,829.60 from the conduct of the Cleveland exhibition. It was decided to refund to the exhibitors 10 per cent of the cost of their space. Also, $1,000 from this amount was transferred to the technical department of the American Foundrymen's Association, Incorporated, and the American Institute of Metals was awarded $166.50. This distribution was based upon the proportionate registration of the two organizations at Cleveland.

All of the meetings of the Board of Directors, of the Executive Committee and the Exhibition Committee were unusually well attended and reflect the continued interest in the affairs of your association by the men to whom you have intrusted its management.

The minutes of the various meetings held throughout the year are presented herewith in full.

Respectfully submitted,

J. P. Pero, Chairman.

A. O. Backert, Secretary.

Board of Directors of the American Foundrymen's Association, Incorporated.

Minutes of Meeting of the Executive Board

Meeting of the Executive Board of the American Foundrymen's Association; Hollenden Hotel, Cleveland, Monday, Sept. 11, 1916.

The meeting of the Executive Board of the American Foundrymen's association held at the Hollenden Hotel, Cleveland, Monday, Sept. 11, 1916, was attended by the following:

R. A. Bull, Commonwealth Steel Co., Granite City, Ill.
A. O. Backert, Cleveland.
S. B. Chadsey, Massey-Harris Co., Toronto, Ont.
H. A. Carpenter, General Fire Extinguisher Co., Providence, R. I.
B. D. Fuller, Westinghouse Electric & Mfg. Co., Cleveland.
A. E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.
C. E. Hoyt, Lewis Institute building, Chicago.
W. A. Janssen, Bettendorf Co., Davenport, Ia.
S. T. Johnston, S. Obermayer Co., Chicago.
V. E. Minich, Sand Mixing Machine Co., New York.
H. D. Miles, Buffalo Foundry & Machine Co., Buffalo.
J. S. Seaman, Seaman-Sleeth Co., Pittsburgh.
R. A. Bull presided.

The question of the consolidation of the American Institute of Metals with the American Foundrymen's association was discussed at length and a motion was made by H. D. Miles and duly seconded, which provided for the appointment of a committee of three to confer with a committee of the American Institute of Metals, or its officers, with reference to the consolidation of the American Institute of Metals with the American Foundrymen's association. This motion was carried without dissent and the chairman, R. A. Bull, announced the appointment of the following committee: B. D. Fuller, chairman; A. E. Howell and A. O. Backert.

Chairman R. A. Bull then presented a resolution, copy of which follows, that provides for the amalgamation and merging of the Amer-

ican Foundrymen's association, an unincorporated society, into the American Foundrymen's Association, Incorporated. This resolution follows:

WHEREAS, The Executive Board of the American Foundrymen's association, an unincorporated society, has formed and organized a corporation not for profit, under the laws of the State of Illinois, to the end of amalgamating and merging this unincorporated association into said American Foundrymen's Association, Incorporated,

NOW THEREFORE BE IT RESOLVED, by the members of the American Foundrymen's association, in annual meeting assembled, as follows:

First.—That the action of the members of the Executive Board of this unincorporated association in forming and incorporating the American Foundrymen's association under the laws of the state of Illinois, be, and the same is hereby, fully ratified, confirmed and approved; and this unincorporated association is hereby declared to be fully, finally and completely amalgamated with, and merged in, said American Foundrymen's Association, Incorporated, under the laws of the State of Illinois, aforesaid.

Second.—That all of the property, assets, moneys and supplies of, or belonging to, this association are hereby transferred to, and declared to be the property, assets, money and supplies of, the said American Foundrymen's Association, Incorporated, upon *CONDITION,* however, that the said incorporated association, shall and does, without reservation or exception, assume, adopt, and agree to pay and discharge and perform all contracts, debts, and obligations of this unincorporated association, keeping this association forever harmless therefrom.

Third.—That upon the acceptance by said American Foundrymen's Association, Incorporated, of the terms and conditions specified in these resolutions, this unincorporated association shall be considered fully and finally dissolved, except that its members and officers may do and perform any act necessary to effectuate in legal form the amalgamation and merger provided for in these resolutions.

WHEREAS, The American Foundrymen's association, an unincorporated society has this day, in annual meeting assembled, passed and adopted certain resolutions in words as follows:

WHEREAS, The Executive Board of the American Foundrymen's Association, an unincorporated society, has formed and organized a corporation not for profit, under the laws of the State of Illinois, to the end of amalgamating and merging this unincorporated association into said American Foundrymen's Association, Incorporated,

NOW, THEREFORE, BE IT RESOLVED by the members of the American Foundrymen's association, in annual meeting assembled, as follows:

First.—That the action of the members of the Executive Board of this unincorporated association in forming and incorporating the American Foundrymen's association under the laws of the state of Illinois, be, and the same is hereby, fully ratified, confirmed and approved; and this unincorporated association is hereby declared to be fully, finally and completely amalgamated with, and merged in, said American Foundrymen's Association, Incorporated, under the laws of the State of Illinois, aforesaid.

Second.—That all of the property, assets, moneys and supplies of or belonging to, this association are hereby transferred to, and declared to be the property, assets, moneys and supplies of, the said American

Foundrymen's Association, Incorporated, upon *CONDITION,* however, that the said incorporated association shall and does, without reservation or exception, assume, adopt and agree to pay and discharge and perform all contracts, debts and obligations of this unincorporated association, keeping this association forever harmless therefrom.

Third.—That upon the acceptance by said American Foundrymen's Association, Incorporated, of the terms and conditions specified in these resolutions, this unincorporated association shall be considered fully and finally dissolved, except that its members and officers may do and perform any act necessary to effectuate in legal form the amalgamation and merger provided for in these resolutions.

NOW, THEREFORE, BE IT RESOLVED, by the American Foundrymen's Association, Incorporated, in annual session duly assembled, that the terms and conditions of the foregoing resolutions adopted by said incorporated association, be, and the same are hereby accepted, approved, ratified and confirmed; and said American Foundrymen's association, unincorporated, is hereby declared to be fully, finally and completely amalgamated with, and merged in, this association, a corporation organized under the laws of the State of Illinois.

BE IT FURTHER RESOLVED, That all persons who are members in good standing of said unincorporated association, are hereby declared to be entitled to membership in this association upon complying with the by-laws of this association relating to the subject of membership.

BE IT FURTHER RESOLVED, That the Board of Directors and other officers of this association are hereby fully authorized and empowered to perform all acts necessary to complete the amalgamation and merger aforesaid according to the terms and conditions set forth in these resolutions.

It was moved by H. A. Carpenter and seconded by H. D. Miles that this resolution be approved and endorsed by the Executive Board and this motion prevailed without dissent.

The chairman, R. A. Bull, outlined briefly a large amount of correspondence which he had with Edgar Marburg, secretary of the American Society for Testing Materials, S. V. Hunnings of committee A-3 of this organization, and Dr. Richard Moldenke, chairman of committee A-3 of the American Society for Testing Materials, relative to specifications for cast iron and the future action of the committee on specifications for gray iron castings of the American Foundrymen's association. It was the contention of Mr. Marburg of the American Society for Testing Materials that the activities of the American Foundrymen's association in the compilation of specifications for gray iron castings, be largely limited to an advisory capacity.

It was moved by H. D. Miles and seconded by W. A. Janssen, that the Executive Board heartily concur in the suggestion made, but that the American Foundrymen's association have representation on committee A-3 of the American Society for Testing Materials and its various sub-committees and that all such specifications for gray iron castings prepared by the American Society for Testing Materials be submitted to the American Foundrymen's association for discussion and ratification. This motion prevailed without dissent.

Motion was made by H. D. Miles and seconded by W. A. Janssen, that the American Foundrymen's association organize a nonferrous section, either by absorbing the membership of the American Institute of Metals, or separately, if such amalgamation cannot be effected. This motion carried without dissent.

It was reported to the Executive Board that the American Foundrymen's association committee on safety and sanitation would present a new safety code for adoption at the annual meeting of the association and in view of the fact that a safety code has been adopted by the National Founders' association, it was suggested that it might be advisable to confer with a committee from the latter organization with a view of harmonizing these two codes and prepare one safety code that would be representative of the entire foundry industry.

It was moved by H. A. Carpenter and seconded by A. E. Howell that co-operation with the National Founders' association in the matter of the adoption of a safety code, be referred to a committee consisting of the president of the American Foundrymen's association and H. D. Miles. This motion was carried without dissent.

During the past year, the American Foundrymen's association became affiliated with the Conference Board on the Training of Apprentices and B. D. Fuller, one of the members of the committee of the American Foundrymen's association representing this organization on this board, recommended that such affiliation be continued. A motion was offered by H. A. Carpenter which was seconded by A. E. Howell, that the affiliation of the American Foundrymen's association with the Conference Board on Training of Apprentices, be continued. This motion prevailed without dissent.

Invitations to affiliate with the National Preparedness League, The United States Chamber of Commerce and the National Fire Protection association, were tabled upon motion by A. E. Howell, seconded by H. D. Miles.

The question of affiliation with the Refractories Manufacturers' association and having representation on some of their committees, was referred to the new committee on steel foundry standards, with full power to act.

The secretary, A. O. Backert, then presented a statement, showing the cost of committee activities in the association, throughout the period from July 1, 1915, to Sept. 11, 1916.

The secretary then was asked to leave the meeting and in his absence the following resolution was adopted:

> As a measure of appreciation, and as a recognition of the extraordinary service performed by A. O. Backert, secretary of the American Foundrymen's association, a motion was presented and duly seconded, that Mr. Backert be paid the sum of $600.00 in addition to this salary for the past year.

There being no further business, the meeting adjourned.

A. O. Backert, Secretary. R. A. Bull, Chairman.

Minutes of Meetings of Board of Directors

MEETING OF THE BOARD OF DIRECTORS OF THE AMERICAN FOUNDRYMEN'S ASSOCIATION, INCORPORATED; HOTEL STATLER, CLEVELAND, WEDNESDAY, SEPT. 13, 1916

At the Wednesday, Sept. 13, session of the annual meeting of the American Foundrymen's association, directors for the ensuing year were elected as follows:

R. A. Bull, Commonwealth Steel Co., Granite City, Ill.
A. O. Backert, Penton Publishing Co., Cleveland.
H. A. Carpenter, General Fire Extinguisher Co., Providence, R. I.
S. B. Chadsey, Massey-Harris Co., Toronto, Ont.
H. S. Covey, Cleveland Pneumatic Tool Co., Cleveland.
Alex. T. Drysdale, U. S. Cast Iron Pipe & Foundry Co., Birmingham, Ala.
S. G. Flagg III, Stanley G. Flagg & Co., Philadelphia.
B. D. Fuller, Westinghouse Electric & Mfg. Co., Cleveland.
C. E. Hoyt, 123 Madison street, Chicago.
A. E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.
W. A. Janssen, Bettendorf Co., Davenport, Ia.
S. T. Johnston, S. Obermayer Co., Chicago.
V. E. Minich, Sand Mixing Machine Co., New York.
J. P. Pero, Missouri Malleable Iron Co., E. St. Louis, Ill.
Jos. T. Speer, Pittsburgh Valve Foundry & Construction Co., Pittsburgh.
H. B. Swan, Cadillac Motor Car Co., Detroit.

The resignations of all of the members of the Board of Directors of the American Foundrymen's Association, Incorporated, effective Sept. 13, 1916, were received by the secretary, prior to the election of the incoming board at the session of the annual meeting of the American Foundrymen's Association, Incorporated.

The meeting of the Board of Directors of the American Foundrymen's Association, Incorporated, held Wednesday evening, Sept. 13, at the Hotel Statler, was attended by the following: R. A. Bull, A. O. Backert, Henry A. Carpenter, S. B. Chadsey, S. G. Flagg III, B. D. Fuller, A. E. Howell, C. E. Hoyt, W. A. Janssen, V. E. Minich, J. P. Pero and H. B. Swan.

R. A. Bull was elected temporary chairman, and A. O. Backert, temporary secretary.

Nominations for the executive officers of the American Foundrymen's Association, Incorporated, to consist of a president, vice president, secretary and treasurer, were next declared in order.

Nominations for the office of president were then called for by the temporary chairman, R. A. Bull, and A. E. Howell nominated J. P. Pero of the Missouri Malleable Iron Co., East St. Louis, Ill., which was seconded by H. B. Swan. Nominations then were closed and J. P. Pero was unanimously elected president of the American Foundrymen's Association, Incorporated, the ballot having been cast by the temporary secretary, A. O. Backert.

Nomination for the office of vice president of the American Foundrymen's Association, Incorporated, were then called for and B. D. Fuller of the Westinghouse Electric & Mfg. Co., Cleveland, was nominated by H. B. Swan, which was seconded by S. G. Flagg III. It was then moved that nominations for the office of vice president be closed and B. D. Fuller was unanimously elected vice president, the ballot having been cast by the temporary secretary, A. O. Backert.

It was moved by R. A. Bull and seconded by W. A. Janssen, that the office of secretary and treasurer be combined. This motion prevailed without dissent.

Nominations for the combined office of secretary and treasurer were then called for and R. A. Bull nominated A. O. Backert of the Penton Publishing Co., Cleveland, which was seconded by A. E. Howell. After the close of nominations, A. O. Backert was elected to the office of secretary and treasurer of the American Foundrymen's Association, Incorporated, the ballot having been cast by the temporary chairman, R. A. Bull.

It was moved by J. P. Pero and duly seconded, that the same Exhibition Committee appointed by the former president, R. A. Bull, hold over until a new committee was appointed by the newly elected president, J. P. Pero. This motion prevailed without dissent.

It was moved by R. A. Bull and duly seconded, that the president, vice president, secretary-treasurer and C. E. Hoyt be appointed a committee to select the time and place of the 1917 annual meeting of the American Foundrymen's Association, Incorporated, and the exhibition to be conducted under its auspices. This motion prevailed without dissent.

It was moved by R. A. Bull and duly seconded, that a committee of seven members of the Executive Board of the American Foundrymen's Association, Incorporated, including the executive officers, be appointed by the president, empowered to act for the entire board on all matters relating to the conduct of the affairs of the American Foundrymen's Association, Incorporated, in the interim between meetings of the Executive Board. This motion prevailed without dissent and the president, J. P. Pero, announced the appointment of the following committee: Maj. Jos. T. Speer, R. A. Bull, H. A. Carpenter, A. E. Howell, C. E. Hoyt, S. T. Johnston and W. A. Janssen.

It was moved by A. E. Howell, and second by R. A. Bull, that the emblem of the American Foundrymen's association be adopted

as the emblem of the American Foundrymen's Association, Incorporated. This motion prevailed without dissent.

At the meeting of the Board of Directors of the American Foundrymen's Association, Incorporated, held at the Hotel Statler, Aug. 6, 1916, the following resolution was adopted:

Resolved, That a per diem of $15 be paid from the funds of the American Foundrymen's Association, Incorporated, to all members of the Board of Directors and committee of this Board of Directors for all meetings which they attend, with the exception of meetings held at the time of the annual conventions. This per diem is to be paid from the time the directors leave their homes until their return. In addition to this per diem of $15, all expenses of the Board of Directors and committees of this Board, are to be paid from the funds of the American Foundrymen's Association, Incorporated, incurred in attending meetings, except those held in connection with the annual conventions.

No per diem is to be allowed any salaried officer of the American Foundrymen's Association, Incorporated, or any officer or director employed by the association on a commission basis. However, the expenses of such salaried officer or officers is to be paid for attendance at all meetings of the Board of Directors of the American Foundrymen's Association, Incorporated, and for expenses incurred in attendance at committee meetings of this Board, unless otherwise provided by contract or other written agreement with the American Foundrymen's Association, Incorporated. The officers engaged on a commission basis shall be allowed their expenses incurred in attendance at meetings of the Board of Directors.

It was moved by R. A. Bull, and seconded by H. A. Carpenter, that this resolution be rescinded and this motion prevailed without dissent.

The following resolution was then offered by R. A. Bull, seconded by H. A. Carpenter, which was unanimously adopted:

Resolved, That a per diem of $10 be paid from the funds of the American Foundrymen's Association, Incorporated, to all members of the Board of Directors and committees of this Board for all meetings which they attend, with the exception of meetings held at the time of the annual conventions. This per diem is to be paid from the time the Directors leave their homes until their return. In addition to this per diem of $10, all expenses of the Board of Directors and committees of this Board, are to be paid from the funds of the American Foundrymen's Association, Incorporated, incurred in attending meetings, except those held in connection with the annual conventions.

No per diem is to be allowed any salaried officer of the American Foundrymen's Association, Incorporated, or any officer or director employed by the association on a commission basis. However, the expenses of such salaried officer or officers is to be paid for attendance at all meetings of the Board of Directors of the American Foundryment's Association, Incorporated, and for expenses incurred in attendance at committee meetings of this Board, unless otherwise provided by contract or other written agreement with the American Foundrymen's Association, Incorporated. The officers engaged on a commission basis

shall be allowed their expenses incurred in attendance at meetings of the Board of Directors.

There being no further business, the meeting adjourned.

A. O. Backert, Secretary. J. P. Pero, Chairman.

Meeting of the Board of Directors of the American Foundrymen's Association, Incorporated; Hotel Statler, Cleveland, Thursday, Sept. 14, 1916

The meeting of the Board of Directors of the American Foundrymen's Association, Incorporated, held at the Hotel Statler, Thursday, Sept. 14, 1916, was attended by the following: R. A. Bull, A. O. Backert, H. A. Carpenter, B. D. Fuller, S. G. Flagg III, A. E. Howell, C. E. Hoyt, S. T. Johnston and V. E. Minich. W. H. McFadden, past president of the association and a member of the Executive Board, also was in attendance.

In the absence of the president, the vice president, B. D. Fuller, was in the chair.

The report of the committee consisting of B. D. Fuller, A. O. Backert and A. E. Howell, previously appointed to consider the amalgamation of the American Institute of Metals with the American Foundrymen's Association, Incorporated, was presented by B. D. Fuller, chairman. It was stated that a conference had been held with a committee appointed by the American Institute of Metals to consider this subject and that the American Institute of Metals had decided not to lose its identity by merging with the American Foundrymen's Association, Incorporated.

It was moved by A. O. Backert, and duly seconded, that the American Institute of Metals share in the appropriation to be made from the net proceeds of the Cleveland exhibition, in the proportion of registered attendance of enrolled members of the American Institute of Metals and the American Foundrymen's Association, Incorporated. That hereafter, namely from the 1917 exhibition and thereafter, no such distribution or any appropriation for technical activities be made to include the American Institute of Metals, but that latter organization share in the entertainment privileges the same as in the past. This motion was adopted without dissent.

It was moved by H. A. Carpenter, and duly seconded, that A. O. Backert be appointed a committee of one, to convey to the secretary of the American Institute of Metals, W. M. Corse, the action taken at this meeting. This motion prevailed without dissent.

In view of the fact that it was impossible for the secretary, A. O. Backert, to have an interview with W. M. Corse on this subject, this information was given to the latter by correspondence.

There being no further business, the meeting adjourned.

B. D. Fuller, Chairman.

A. O. Backert, Secretary.

Meeting of the Board of Directors of the American Foundrymen's Association, Incorporated; Hotel Anderson, Pittsburgh, June 17, 1917

For the purpose of discussing the advisability of sending a commission representing the American Foundrymen's association to England and France for the purpose of investigating the manufacture of cast iron shells and hand grenades, as well as other subjects of equal importance, a meeting of the Board of Directors was held at the Hotel Anderson, Pittsburgh, June 17.

This meeting was attended by the following: J. P. Pero, Maj. Jos. T. Speer, A. E. Howell, R. A. Bull, B. D. Fuller, W. A. Janssen, H. A. Carpenter, V. E. Minich, S. T. Johnston, S. Griswold Flagg III, C. E. Hoyt and A. O. Backert.

The question of opening the convention on Tuesday morning, Sept. 25, in place of Monday afternoon, Sept. 24, was considered at length and upon motion offered by B. D. Fuller, seconded by Maj. Jos. T. Speer, it was decided to have the opening session on Tuesday morning in place of on Monday afternoon as at Cleveland last year. Single sessions will be held daily with the exception of simultaneous meetings which are to be arranged for the discussion of gray iron, steel and malleable topics.

The action of the president in enlarging the committee known as "Representatives on the Conference Board on Training of Apprentices", was approved upon motion offered by Henry A. Carpenter, and seconded by B. D. Fuller. This committee consists of J. P. Pero, ex-officio; B. D. Fuller, F. W. Leavitt, C. E. Hoyt, C. B. Connelley, W. B. Hunter, Director Industrial Department, Fitchburg High School, Fitchburg, Mass., and Stewart Schrimshaw, Industrial Commission of Wisconsin, Madison, Wis. The president stated that he would appoint on this committee also, E. A. Johnson, Wentworth Institute, Boston. This committee will jointly consider a course of training for apprentices, as well as the preparation of apprenticeship indentures.

The salary of the secretary's assistant, E. Thomas, was increased from $65 to $75 per month, the additional $10 to be charged against the Exhibition Department, making Mr. Thomas' salary $25.00 per month from the Exhibition Department and $50.00 per month from the Technical department. It was moved by C. E. Hoyt, and seconded by R. A. Bull, that Mr. Thomas' salary be increased to $75 per month dating from July 1, 1917. This motion carried without dissent.

It was suggested that a committee be appointed to call on the car supply committee of the Council of National Defense at Washington, D. C., with a view of obtaining preferential shipments on foundry materials. After considerable discussion it was moved by R. A. Bull,

and seconded by S. Griswold Flagg III, that the suggestion be tabled indefinitely. The motion prevailed.

Several months ago, President J. P. Pero suggested that the association might aid the ordnance department of the government by sending a commission of three to England and France for the purpose of investigating and studying the manufacture of cast iron shells and hand grenades. Letters were sent to Howard E. Coffin, chairman of the Advisory Commission of the Council of National Defense offering such service, with the request that this commission receive government recognition in order that it may secure admission to the munitions works abroad. President Pero's letter was supplemented by correspondence by the secretary and advice was received that the government was not yet ready for such commissions, nor are the munitions experts of the government satisfied that cast iron shells have proved successful. Motion was made by Henry A. Carpenter, and seconded by S. Griswold Flagg III, that the appointment of this commission be held in abeyance until further advice is received from the government. This motion prevailed unanimously.

The secretary was instructed to publish all of the correspondence on this subject in the report of the Board of Directors to be presented at the annual meeting of our Association to be held in Boston.

The advisability of holding the annual banquet this year was discussed at length, since some of the directors were of the opinion that the banquet should be eliminated to further the effort that is being made to conserve the country's food supply. Motion was made by Henry A. Carpenter, and seconded by A. E. Howell, that a committee consisting of the president, secretary and one other be appointed to consider the banquet question. This motion was amended by C. E. Hoyt and seconded by A. E. Howell, to included Henry A. Carpenter as a member of this committee. The amendment prevailed and the original motion by Henry A. Carpenter also was carried. The committee appointed, therefore, consists of the president, secretary and Henry A. Carpenter.

The president then polled the members of the board to ascertain their sentiments with reference to the elimination of the banquet feature entirely. Three of the directors were in favor of its elimination this year; four were opposed, while the remaining five would not express an opinion, as they believed that within the next 60 days developments would be such as to make a more satisfactory decision possible than at the present time.

It was the concensus of opinion that if no banquet is held, a patriotic meeting should take its place and in either event, speakers of national reputation should be secured to deliver addresses. It was suggested that an effort be made to obtain former Presidents Theodore Roosevelt or Wm. H. Taft. Others recommended included Howard E.

Coffin, W. H. Vandervoort, former German Ambassador Gerard, Leslie Shaw, and Capt. Reith of the Eddystone Munitions Co. Upon motion made by R. A. Bull, and seconded by C. E. Hoyt, the selection of speakers was referred to a committee consisting of the president, vice president and secretary.

There being no further business, the meeting was adjourned.

J. P. PERO, Chairman.

A. O. BACKERT, Secretary.

Minutes of Meetings of Executive Committee of Board of Directors

Meeting of the Executive Committee of the Board of Directors of the American Foundrymen's Association, Incorporated; Anderson Hotel, Pittsburgh, Dec. 17, 1916

The first meeting of the Executive Committee of the Board of Directors of the American Foundrymen's Association, Incorporated, was held at the Anderson hotel, Pittsburgh, Dec. 17, 1916. It was attended by the following: R. A. Bull, Commonwealth Steel Co., Granite City, Ill; A. O. Backert, Cleveland; Henry A. Carpenter, General Fire Extinguisher Co., Providence, R. I.; B. D. Fuller, Westinghouse Electric & Mfg. Co., Cleveland; Alfred E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.; C. E. Hoyt, Lewis Institute building, Chicago; W. A. Janssen, Bettendorf Co., Davenport, Ia.; S. T. Johnston, S. Obermayer Co., Chicago, and Maj. Jos. T. Speer, Pittsburgh Valve Foundry & Construction Co., Pittsburgh.

In the absence of the president, J. P. Pero, the vice president, B. D. Fuller, presided.

The secretary presented an outline of the plan that was being considered by the Cost Committee, which provides for the raising of a fund to be subscribed by the members of the association participating in this work and the employment of a cost expert to prepare a uniform system of cost accounting to bear the endorsement of the American Foundrymen's Association, Incorporated, and which is to be installed personally by the cost accountant to be employed by the Cost Committee of the American Foundrymen's Association, Incorporated. Propositions covering this work received from Scovell, Wellington & Co., Boston, C. E. Knoeppel & Co., New York, and Searle & Nicholson, New York, were read.

Motion was made by Henry A. Carpenter, and seconded by R. A. Bull, that the Cost Committee of the American Foundrymen's Association, Incorporated, be authorized to carry out the plan as outlined. This motion prevailed without dissent.

The following resolution adopted by the Exhibition Committee of the American Foundrymen's Association, Incorporated, at its meeting held at Pittsburgh, December 16, then was presented:

Resolved, That it be recommended to the Board of Directors of the American Foundrymen's Association, Incorporated, that a cash rebate of 10 per cent be paid to the exhibitors at the Cleveland show held Sept. 11-16, 1916, on the basis of floor space occupied, this sum

to be charged against the profits which have accrued from the conduct of this exhibition.

Furthermore, That each exhibitor should receive a summary of the auditor's report showing the income, expenditures and earnings of the Cleveland show and that the secretary be instructed to mail such a statement to each exhibitor accompanied by a check covering his rebate.

Furthermore, That the sum of $1000 be transferred from the exhibition account to the account of the technical department of the American Foundrymen's Association, Incorporated, based on the registration of 889 members at the Cleveland convention and the sum of $166.50 be paid to the American Institute of Metals based on a registration of 148 members at the Cleveland meeting. This distribution is based upon the proportionate registration of the conventions of the American Foundrymen's Association, Incorporated, and the American Institute of Metals, respectively.

Furthermore, That the balance in the fund credited to the Exhibition Account is to be retained in the treasury of the exhibition department of the American Foundrymen's Association, Incorporated.

It was moved by R. A. Bull, and seconded by C. E. Hoyt, that the recommendations of the Exhibition Committee, as contained in the foregoing resolution, be adopted. This motion prevailed without dissent.

A motion then was offered by Henry A. Carpenter, and seconded by W. A. Janssen, that the thanks of the American Foundrymen's Association, Incorporated, be extended to the Exhibition Committee and to each member of this committee, individually, for the excellent services rendered in the conduct of the Cleveland Exhibition; that all of its acts be ratified and that the committee be discharged without further service. This motion was adopted unanimously.

It was moved by R. A. Bull, and seconded by A. E. Howell, that the president be authorized to appoint an Exhibition Committee of eight members of which he is to be ex-officio chairman, with authority to select a manager to conduct the 1917 exhibition. This motion prevailed without dissent.

Motion was made by S. T. Johnston, and seconded by Maj. Jos. T. Speer, that the treasurer of the American Foundrymen's Association, Incorporated, be instructed to transfer the sum of $1000 from the exhibition account to the technical account of the American Foundrymen's Association, Incorporated, also to pay the sum of $166.50 to the American Institute of Metals and to rebate to the exhibitors, 10 per cent of the sum paid for space in proportion to the amount of space occupied. This motion prevailed without dissent.

The secretary then presented the following resolution which was adopted at a meeting of the Cleveland Foundrymen's Local Committee, held at Cleveland, Dec. 11, 1916:

Whereas, It is the concensus of opinion of the members of the General Committee of the Cleveland Foundrymen's Local Committee that a fund for research work should be established by the American Foundrymen's association to promote investigations of subjects relating

to the technical side of the foundry industry only; and to further this investigation and to enable the establishment of such a fund, be it therefore,

Resolved, That the balance remaining in the entertainment fund subscribed to by foundrymen of Cleveland and vicinity, manufacturers of foundry equipment and supplies, etc., for the entertainment of the members of the American Foundrymen's Association, Incorporated, and the American Institute of Metals, amounting to $335.86, be contributed to the American Foundrymen's association for research work and be devoted for that purpose only.

It is suggested that this practice initiated by the Cleveland Foundrymen's local committee be followed by other similar committees privileged to entertain the American Foundrymen's Association, Incorporated, in annual convention and that they contribute any balances remaining in entertainment funds from subscriptions raised for entertainment purposes, to this fund for research work.

It is with a view of promoting the magnificent work that is being done by the American Foundrymen's association that this balance is being contributed and it is hoped that the Board of Directors of the American Foundrymen's association will accept this sum for the purpose for which it is intended.

It was moved by R. A. Bull and seconded by S. T. Johnston that the generous offer made by the Cleveland Foundrymen's Local Committee, which involves the contribution of $335.86 for the establishment of a research fund, be accepted. This motion was carried unanimously.

The following resolution, presented by R. A. Bull, seconded by S. T Johnston, copy of which is to be forwarded to the members of the Cleveland Foundrymen's Local Committee, was adopted:

WHEREAS, The Cleveland Foundrymen's Local Committee, through whose efforts the members of the American Foundrymen's Association, Incorporated, were so hospitably entertained in convention during the week of Sept. 11-16, 1916, has offered to contribute the balance remaining in its entertainment fund amounting to $335.86, to the American Foundrymen's Association, Incorporated, to form the nucleus of a fund for research work, therefore,

BE IT RESOLVED, That this sum be accepted in the same generous and whole-hearted spirit which prompted its offer for the purpose for which it is intended.

The Executive Committee of the American Foundrymen's Association, Incorporated, on behalf of its Board of Directors and members at large, extends its sincere thanks to the Cleveland Foundrymen's Local Committee for this sum, which is hereby accepted and the secretary is instructed to convey to each member of this committee, a copy of this resolution.

It was recommended that the name of the committee on Safety and Sanitation be changed to include fire protection and that this committee be known in the future as the Committee on Safety, Sanitation and Fire Protection. It was further recommended that the president appoint an additional member on this committee to represent the fire protection interests.

It was moved by R. A. Bull and seconded by W. A. Janssen that this recommendation be adopted. This motion prevailed without dissent.

The apprenticeship question was discussed at length and it was the concensus of opinion that notwithstanding the representation of the American Foundrymen's association on the Conference Board on Training of Apprentices, that this organization should investigate this problem independently and to further this work, it is recommended to the president that he appoint two additional members to serve on this committee and that it make a survey of representative schools whose curriculum is designed to assist in the training of molders. Furthermore, he was authorized to expend for this work, a sum not to exceed $500.

It was moved by W. A. Janssen and seconded by Henry A. Carpenter that the foregoing recommendations be adopted and this motion was carried without dissent.

It was moved by Maj. Jos. T. Speer and seconded by W. A. Janssen that the committee of four to select the time and place of the 1917 convention, be increased from four to six members and it was recommended that the president appoint V. E. Minich, Sand Mixing Machine Co., New York, and S. T. Johnston, S. Obermayer Co., Chicago, additional members of this committee. It also was recommended that the president appoint R. A. Bull as alternate. This motion was carried unanimously.

It was moved by Henry A. Carpenter and seconded by Maj. Jos. T. Speer, that it is the consensus of opinion of the members of the Executive Committee of the Board of Directors, that the 1917 convention of the American Foundrymen's Association, Incorporated, and the exhibition to be conducted under its auspices, be held in Boston next year and that the secretary be instructed to convey this expression of opinion to the committee of six to decide upon the time and place of the 1917 gathering. This motion prevailed unanimously.

Motion was made by Henry A. Carpenter and seconded by S. T. Johnston, that the committee of six, of which R. A. Bull is an alternate, be instructed to meet at the Hotel Kimball, Springfield, Mass., Friday, Jan. 5, and at the Copley-Plaza Hotel, Boston, Jan. 6, 1917, to investigate the propositions offered by these two cities, their hotel facilities and their exhibition halls, with a view of definitely deciding upon the time and place of the 1917 convention. This motion prevailed without dissent.

It was the consensus of opinion that the 1917 annual meeting and convention be held during the week of Sept. 24, and the secretary was instructed to obtain options if possible on the exhibition buildings at Boston and Springfield until a definite decision can be reached by the special committee of six.

There being no further business the meeting was adjourned.

BENJ. D. FULLER, Chairman.

A. O. BACKERT, Secretary.

Meeting of the Executive Committee of the Board of Directors of the American Foundrymen's Association, Incorporated, Hotel La Salle, Chicago, Jan. 28, 1917.

The second meeting of the Executive Committee of the Board of Directors of the American Foundrymen's Association, Incorporated, was held at the Hotel La Salle, Chicago, Jan. 28, 1917.

It was attended by the following: J. P. Pero, Missouri Malleable Iron Co., East St. Louis, Ill.; R. A. Bull, Chicago Steel Foundry Co., Chicago; A. E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.; B. D. Fuller, Westinghouse Electric & Mfg. Co., Cleveland; W. A. Janssen, Bettendorf Co., Davenport, Ia.; S. T. Johnston, S. Obermayer Co., Chicago; C. E. Hoyt, Chicago, and A. O. Backert, Cleveland.

J. P. Pero, president, presided.

The committee appointed to select the time and place of the 1917 convention and exhibition reported that its selection was Boston, Mass., for the week of Sept. 24, 1917, satisfactory arrangements having been made for the conduct of the exhibition in Mechanics' building, although no contract has yet been entered into. A. E. Howell made a motion, seconded by W. A. Janssen that the action of the committee be endorsed. This motion was adopted without dissent.

The chairman, J. P. Pero, announced the appointment of H. A. Carpenter, General Fire Extinguisher Co., Providence, R. I., and F. C. Eggelston, Chicago Pneumatic Tool Co., Boston, Mass., as successors on the Exhibition Committee to Maj. Jos. T. Speer and H. S. Covey, respectively.

At the request of the executive officers of the association, C. E. Hoyt was requested to investigate the exhibition facilities at Boston and New York, December 11-16, and he later served as a member of the Special Committee of seven on the trip to Springfield and Boston, January 4 to 11. It was moved by R. A. Bull and seconded by S. T. Johnston, that Mr. Hoyt be paid a per diem of $10.00 for the periods covered by these trips, in addition to his regular expenses. This motion prevailed without dissent.

It was reported by the Special Committee appointed to select the time and place of the 1917 convention and exhibition, that the hotels of Boston have promised tentatively, the sum of $500 toward defraying the cost of the annual banquet, to which the Copley-Plaza Hotel would contribute the sum of $250. It was moved by C. E. Hoyt and seconded by R. A. Bull, that the Copley-Plaza Hotel be selected as headquarters for the American Foundrymen's Association, Incorporated, subject to a satisfactory agreement with the Copley-Plaza for the payment of the sum of $250, the maintenance of commercial rates

throughout convention week and the making of reservations on a satisfactory basis. This motion prevailed without dissent.

It was moved by A. E. Howell and seconded by B. D. Fuller, that the president, J. P. Pero, the secretary, A. O. Backert and the exhibition manager, C. E. Hoyt, be empowered to attend to all of the details in connection with the conduct of the Boston exhibition, with the understanding that all matters of major importance be referred to the Exhibition Committee. The motion prevailed unanimously.

A motion was made by A. E. Howell and seconded by R. A. Bull, that a sum not to exceed $3000 be appropriated to defray the expenses of advertising the 1917 convention and exhibition. This motion carried without dissent.

It was moved by R. A. Bull and seconded by A. E. Howell that the emblem of the association be adopted as the official seal and that the following by-law, to be known as "Article X" with the caption, "Seal and Emblem," be unanimously adopted.

Article X. Seal and Emblem

Section 1.—The emblem of the association shall be of circular form with the initials of the association and the date of organization of the unincorporated association occupying the cardinal points and connected by double rings. Crossing said rings at right angles, and joined in the center by a vertically placed trowel, a rammer and shovel shall be represented.

Section 2.—Pins or other articles bearing the emblem of the association may in the discretion of the Board of Directors, be purchased by the association and issued or sold to members.

Section 3.—The seal of the association shall be a reproduction of the emblem, with sufficient additional space on the circumference to show these words surrounding the emblem proper: "Seal of American Foundrymen's Association, Inc."

The foregoing by-law was adopted unanimously.

It was moved by A. E. Howell and seconded by R. A. Bull, that H. Cole Estep, of Cleveland, be appointed Assistant to the Secretary at a salary of $50.00 per month, beginning Feb. 1, 1917. This motion was carried unanimously.

At the annual meeting of the association held at Cleveland, Sept. 11-16, 1916, the Board of Directors was authorized to adopt the Government Standard for Sieves as prepared by the United States Bureau of Standards. It was moved by R. A. Bull and seconded by W. A. Janssen that this standard be adopted and the motion prevailed unanimously.

At the annual meeting of the association held at Cleveland, Sept. 11-16, 1916, a resolution was adopted providing that the representatives of the American Foundrymen's association on the Conference Board on Training of Apprentices be empowered to draft apprenticeship regulations and to submit them to the Board of Directors for whatever action it might be desirable to take.

Another resolution was also adopted at that meeting, providing for the appointment of a committee to consider suitable apprentice indentures and that the information received from this investigation be sent to all of the members of the association. However, the appointment of this committee must first be sanctioned by the Board of Directors of the American Foundrymen's Association, Incorporated.

It was moved by R. A. Bull and seconded by B. D. Fuller that action on both of these resolutions be deferred until further information is available. This motion prevailed unanimously.

Clinton H. Scovell, of Scovell, Wellington & Co., Boston, at the request of the committee, discussed at length his facilities for carrying out the uniform cost work planned by the American Foundrymen's Association, Incorporated, in the event of favorable action upon his proposition by the Cost Committee which is empowered to enter into a contract for carrying on this work.

There being no further business, the meeting adjourned.

J. P. PERO, Chairman.

A. O. BACKERT, Secretary.

Minutes of Meeting of 1916 Exhibition Committee

Meeting of the 1916 Exhibition Committee of the American Foundrymen's Association, Incorporated; Hotel Anderson, Pittsburgh, Dec. 16, 1916.

A meeting of the 1916 Exhibition Committee of the American Foundrymen's Association, Incorporated, held at the Hotel Anderson, Pittsburgh, Dec. 16, 1916, was attended by the following: R. A. Bull, Granite City, Ill.; A. O. Backert, Cleveland; H. S. Covey, Cleveland Pneumatic Tool Co., Cleveland; A. E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.; S. T. Johnston, S. Obermayer Co., Chicago; V. E. Minich, Sand Mixing Machine Co., New York and Maj. Jos. T. Speer, Pittsburgh Valve Foundry & Construction Co., Pittsburgh.

R. A. Bull, chairman of the committee presided. President J. P. Pero was unable to attend.

C. E. Hoyt, Lewis Institute building, Chicago, exhibition manager, under whose auspices the Cleveland show, Sept. 11-16, 1916, was conducted, presented a detailed report accompanied by a financial statement which forms a part of these minutes. In addition, he submitted a report of the examination of the financial affairs of the exhibition, made by Ernst & Ernst, certified public accountants, Chicago.

A motion was made by Maj. Jos. T. Speer and seconded by V. E. Minich, that the report submitted by C. E. Hoyt and the financial statement by Ernst & Ernst, be accepted and constitute a part of these minutes. This motion prevailed without dissent.

The following resolution was offered by S. T. Johnston and seconded by Maj. Jos. T. Speer:

Resolved, That it be recommended to the Board of Directors of the American Foundrymen's Association, Incorporated, that a cash rebate of 10 per cent be paid to the exhibitors at the Cleveland show, held Sept. 11-16, 1916, on the basis of floor space occupied; this sum to be charged against the profits which have accrued from the conduct of the exhibition.

Furthermore, That each exhibitor receive a summary of the auditor's report showing the income, expenditures and earnings of the Cleveland show and that the secretary be instructed to mail such a statement to each exhibitor accompanied by a check, covering the rebate.

Furthermore, That the sum of $1000 be transferred from the Exhibition account to the Technical Department of the American Foundrymen's Association, Incorporated, based on the registration of

889 members at the Cleveland convention, and that the sum of $166.50 be paid to the American Institute of Metals, based on the registration of 148 members at the Cleveland meeting. The distribution is based upon the proportionate registration at the conventions of the American Foundrymen's Association, Incorporated, and the American Institute of Metals.

Furthermore, That the balance in the fund credited to the Exhibition Account is to be retained in the treasury of the Exhibition Department of the American Foundrymen's Association, Incorporated.

The foregoing resolution was adopted unanimously.

There being no further business to be transacted by the 1916 Exhibition Committee, it adjourned *sine die.*

R. A. Bull, Chairman.

A. O. Backert, Secretary.

Report of the Department of Exhibits

Dec. 15, 1916.

To the Committee on Exhibits,
American Foundrymen's Association, Inc.

Gentlemen:

We are pleased to submit the following report covering the first foundry and shop equipment exhibit under the auspices of the American Foundrymen's Association, Incorporated.

This exhibit was held during the week of Sept. 11, 1916, at Cleveland, and was installed in the Wigmore Coliseum, and in a combination tent and building erected for the purpose. In all 151 firms participated, 146 of whom made exhibits, using a total of 37,933 square feet of space, an average of 261 square feet per exhibitor. The largest individual space user was the Gardner Machine Co., Beloit, Wis., with 1036 square feet.

For your information, we have classified the exhibits as follows:

		Sq. ft.
Foundry Equipment and Supplies.........	82 exhibitors, using	21,852
Pattern Shop Machinery and Supplies.....	6 exhibitors, using	2,220
Machine Shop Machinery and Supplies....	8 exhibitors, using	2,345
Trade Publications	7 exhibitors, using	2,245
Unclassified	43 exhibitors, using	10,144

Of the 146 exhibitors, 110 had exhibited at one or more previous conventions of the American Foundrymen's association, and 35 were new exhibitors. The average amount of space used per exhibitor was considerably less than that of other years, largely accounted for by business conditions, which made it extremely difficult for manufacturers to obtain machines for display. However, in the total number of exhibits, the extent to which the various lines were represented, especially in foundry equipment, and in the interest shown, the 1916 exhibit was a most successful one. The auditor's report and our financial statement which we will read later, shows the Department of Exhibits in good condition at the end of its first year. We would call attention to the fact that our present bank balance resulted entirely from the earnings of this exhibit, as the Department was started last March without funds.

New policies were inaugurated this year to which it might be well to call attention, namely, waiving admission charge to members of the American Foundrymen's association and the American Institute of Metals, and the giving of one admission pass to each exhibitor, and making no charge for power used in operating the exhibits. The free admissions probably reduced our gate receipts $800, and had we made a charge for power at the rates charged at previous exhibits our receipts would have been increased $1300.00 more, or something over $2000.00 altogether.

Labor and material prices were considerably increased, although the price for space remained the same as for the past eight years. The largest individual item of expense was the temporary building, the contract price being $2600.00, the extra labor, wiring, booth construction, piping, etc., brought the cost well over $3000.00 in excess of what it would have been could the Coliseum have accommodated all of our exhibitors.

With this report we submit copy of the auditor's report and below will be found a more detailed financial statement showing the receipts and expenditures:

RECEIPTS

From Cleveland Chamber of Commerce (Guarantee)	$1,000.00
Space Rental	20,228.70
Exhibitor's Permits	3,825.00
Gate Receipts	2,030.25
Interest on the bank balance	43.98
	$27,127.93

EXPENSES

Administration		$5,793.30
Printing:		
Stationery, circulars, rules and regulations, applications, contracts, tags, tickets	$378.90	
Circular letters	43.63	
Invitations and programs	4,471.38	
Official directory and program	259.93	1,153.84
Postage		485.00
Committee Travel		1,248.68
Advertising:		
Stickers	245.15	
Calendars	621.27	
Electric sign	75.00	
The Foundry	408.54	
The Iron Trade Review	298.24	
Metal Industry	81.68	
Railway Mechanical Review	125.00	
Iron Age	503.00	
Canadian Foundryman	93.00	
The Brass World and Plater's Guide	80.00	2,530.88
Secretary's Assistant		60.00

General Expense:			
Cartage and water cooler service......		40.15	
Power:			
Division of Heat and Light, City of Cleveland, for installation and current	413.43		
Illuminating Co., for installation and current	68.00		
East Ohio Gas Co...................	1.18		
Elliott Electric Co., contract...........	2,186.10		
Piping for compressed air:			
Schneider Plumbing Co..............	288.08		
Cleveland Tool & Supply Co.........	48.88		
Freight and cartage on air compressor	213.72		
	3,219.39		
Less Exhibitors' power accounts......	1,484.59	1,734.80	
Annex		2,686.35	
Telephone and Telegraph, Chicago........	27.35		
Telephone and Telegraph, Cleveland......	135.35	162.70	
Booths:			
Rental on material and supervision....	750.20		
Freight and cartage.................	328.52		
Labor and expense of erection......	770.63		
Extra material	186.62		
Decoration	150.00	2,185.97	
Signs		240.65	
Manager's and assistants' traveling expense:			
C. E. Hoyt...........................	248.13		
W. H. Schulte........................	172.78		
J. Reininga..........................	133.74		
E. C. Hall	116.24		
J. H. Kellogg	49.83	720.72	
Registration:			
Clerical help........................	73.00		
Printing	97.00		
Supplies	30.45	200.45	
Watchmen and janitor service..........		306.54	
Labor, removing boxes, etc.............		281.39	
Insurance		32.65	
Badges		434.26	$20,298.33
			6,829.60

It will be seen from the above, that the total expense of the department of exhibits for the year is $69.63 in excess of the amount received for space rental. We find that the average cost of space

per square foot was 53.3 cents per square foot of space sold. The distribution of expense on the per square foot basis is as follows:

	Cents
Administration (including manager's salary, manager's and secretary's assistants, all traveling and office expense exclusive of the Executive Committee)	17.34
Printing	3.04
Committee travel	3.3
Advertising	6.4
Power	4.56
Booths and signs	6.13
Annex	7.08
All other expense	5.12

In addition to the cash assets of the department, we have the electrical material consisting of wire, switches, fuses, etc., which were used for power. The cost of this material was $899.60. The allowance stipulated in our contract in the event of the material being returned to the electrical contractors was 20 per cent of the cost or $179.92, and we believe it would be proper to inventory this material at that price, which would increase our assets to $7,009.52.

In the statement of receipts shown, it will be noted that there is no item covering the receipts for the cost of power installation. This item, which amounted to $1,484.59, is accounted for under Power in the above statement.

Respectfully submitted,

DEPARTMENT OF EXHIBITS,
C. E. Hoyt, Manager.

Minutes of Meetings of 1917 Exhibition Committee

MEETING OF THE 1917 EXHIBITION COMMITTEE OF THE AMERICAN FOUNDRYMEN'S ASSOCIATION, INCORPORATED; HOTEL LA SALLE, CHICAGO, JAN. 28, 1917.

The meeting of the Exhibition Committee of the American Foundrymen's Association, Incorporated, held at the Hotel La Salle, Chicago, Jan. 28, 1917, was attended by the following: J. P. Pero, R. A. Bull, A. E. Howell, S. T. Johnston and A. O. Backert.

The president, J. P. Pero, ex-officio chairman, presided.

This meeting, although not called in advance, was announced and called to order by the president, J. P. Pero, at the time of the meeting of the Executive Committee of the Board of Directors, held at the Hotel La Salle, Jan. 28, 1917. A quorum of the Exhibition Committee being present and for the purpose of expediting matters in connection with the conduct of the 1917 exhibition, it was deemed advisable to hold this meeting although three of the members of the committee did not receive previous advice to this effect.

The president, J. P. Pero, announced the appointment of H. A. Carpenter, General Fire Extinguisher Co., Providence, R. I., and F. C. Eggelston, Chicago Pneumatic Tool Co., Boston, as members of this committee to succeed Maj. Jos. T. Speer, Pittsburgh Valve Foundry & Construction Co., Pittsburgh, and H. S. Covey, Cleveland Pneumatic Tool Co., Cleveland.

The employment of a manager to conduct the 1917 exhibition at Boston was considered at length. C. E. Hoyt, manager of the Cleveland exhibition, held Sept. 11-16, 1916, presented a proposition for the conduct of the Boston show and after its presentation, he was requested to leave the room to enable the committee to consider its provisions.

Upon motion made by R. A. Bull and seconded by S. T. Johnston, it was decided to enter into a contract with C. E. Hoyt. Lewis Institute building, Chicago, for the conduct of the 1917 exhibition at Boston, to be held during the week of Sept. 24, and the contract to be entered into with him was prepared by the committee, subject to the approval of the absent members of the committee, H. A. Carpenter, V. E. Minich and F. C. Eggelston. This motion prevailed without dissent.

It was announced that the Executive Committee of the Board of Directors of the American Foundrymen's Association, Incorporated, appropriated a sum not to exceed $3000 for defraying the

expenses of conducting the publicity campaign for the 1917 exhibition. It also was announced that the Executive Committee of the Board of Directors appoint a Special Committee, consisting of the president, secretary and exhibition manager, empowered to attend to all of the details of the conduct of the Boston exhibition with the understanding that all matters of major importance be referred to the Exhibition Committee for final decision.

There being no further business, the meeting adjourned.

J. P. Pero, Chairman.

A. O. Backert, Secretary.

Meeting of the 1917 Exhibition Committee of the American Foundrymen's Association, Incorporated; Hotel Anderson, Pittsburgh, June 17, 1917

With one exception, all of the members of the 1917 exhibition committee of the American Foundrymen's Association, Incorporated, were in attendance at the meeting of the Board of Directors and, therefore, at the conclusion of the meeting of the board, a meeting of the exhibition committee was called.

The following were in attendance: J. P. Pero, B. D. Fuller, R. A. Bull, Henry A. Carpenter, A. E. Howell, S. T. Johnston, V. E. Minich and A. O. Backert.

Exhibition Manager C. E. Hoyt presented a report on the progress of the Boston exhibition and he reported that 94 applications for space had been received aggregating an estimated total of 30,000 square feet. Mr. Hoyt suggested that the builders of motor trucks be invited to make exhibits this year, owing to the fact that these vehicles are being generally employed for conveying foundry materials, castings, machine tools, etc. Upon motion by A. E. Howell, seconded by Henry A. Carpenter, the following resolution was adopted:

> *Whereas,* Motor-driven vehicles are being generally employed for conveying foundry materials, machine tools and accessories, and owing to the unusual interest manifested by the members of the American Foundrymen's association and allied bodies in the introduction and use of motor-driven vehicles for employment in the handling of their raw material and finished product,
>
> *Therefore be it resolved,* that an invitation be extended to the manufacturers of motor trucks to exhibit their vehicles this year in conjunction with the display of foundry equipment and supplies, machine tools and accessories, to be held in Mechanics' building, Boston, Sept. 24, 25, 26, 27, 28, inclusive.

There being no further business, the meeting adjourned.

A. O. Backert, Secretary. J. P. Pero, Chairman.

Annual Report of the Secretary-Treasurer

To the President and members of the American Foundrymen's Association, Incorporated:

It is gratifying to report that during the fiscal year, ending June 30, 1917, the membership of your association passed the 1000-mark and on that date the enrollment attained a total of 1017. In the 12-month period from July 1, 1916, to June 30, 1917, 147 foundrymen were admitted to membership, of which 124 were active and 23 associate. The resignations aggregated 48, and 49 members were dropped for non-payment of dues. While the total book membership was 1017 on June 30, the total paid enrollment on this date was 970, as compared with 918 the previous year. Therefore, the actual paid membership showed a gain for the year of 52 or 5.5 per cent. The associate membership on June 30, this year, was 124, against 150 a year ago, a decline of 26. This apparent lack of interest in the affairs of your association by those entitled to this associate privilege is to be deplored and it is suggested that the active members endeavor to enlist the interest of their superintendents and foremen in the activities of this body. Ever since the Associated Foundry Foremen were merged with this association, the associate membership has steadily declined. It is possible that these members feel that the material benefits derived from such affiliation is not in proportion to the expenditure and it is suggested that a reduction in the price of *The Transactions* be made to associate members who desire to retain the record of our annual meetings in permanent form. Although several successful campaigns for membership have been conducted during the year, nevertheless the aid and support of the members is urged in enlisting the interest of foundrymen generally in the work of our society.

The expense involved in conducting the affairs of your association has increased steadily and while the treasury showed a balance at the end of the fiscal year, nevertheless it might

be necessary to increase the dues slightly to cover the added cost of operation. Several technical societies have been compelled to take this step, and while it is not urged for immediate consideration, nevertheless, constantly mounting costs may compel this action within a year to provide sufficient revenue to conduct the affairs of the association. The board of directors authorized the employment of an assistant to the secretary at a salary of $50 per month. He is serving largely in an editorial capacity and has greatly reduced the burden of the secretarial office.

Complete data, covering the membership, follow:

	June 30, 1917	
Active members, good standing	861	
Active members, delinquent	16	
Active members carried on books		877
Associate members, good standing	109	
Associate members, delinquent	15	
Associate members carried on books		124
Honorary members		16
Total book membership		1,017

Total membership paid to June 30, 1917	970
Total membership paid to June 30, 1916	918
Gain for year, 5.5 per cent, or	52
Resignations during year	48
Dropped for non-payment of dues	49

New members received during year 1916-1917, 147, of which 124 were active and 23 associate.

Accompanying this report is a chart, showing the membership of the American Foundrymen's association by years since the date of its organization in 1896.

Finances

Increased operating expenses were more than balanced by the enhanced revenue, the receipts having exceeded the disbursements by $391.13 and the cash on deposit June 30, 1917, was $594.85, as compared with $203.72 the previous year. The

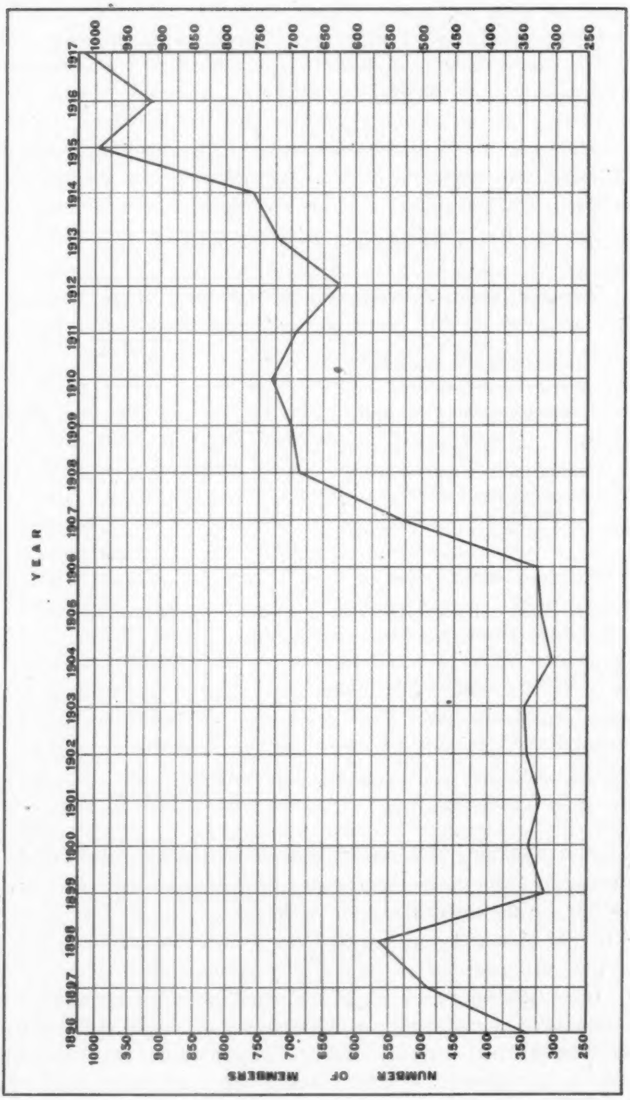


CHART SHOWING FLUCTUATION IN MEMBERSHIP FROM 1896 TO 1917

total receipts were $16,582.60, of which $1000 was transferred from the profits of the Cleveland exhibition and $337.11 was set aside as a research fund to be drawn upon for special investigations to be authorized by the board of directors. This fund was established by the local committee in charge of the entertainment and reception of the foundrymen at Cleveland last year and represented the balance in the local fund after all expenses were paid. Thus far it has not been drawn upon and it is hoped that it may be increased materially before special work is authorized. The inventory of supplies, furniture and fixtures, emblems, unpaid balance due on the exhibition account and the balance of the American Foundrymen's cost work account aggregated $1,932.07. The disbursements were $16,191.47, the receipts having exceeded the expenditures by $391.13.

At Cleveland last year your association undertook, for the first time, the management of the exhibition of foundry supplies and equipment and machine tools and accessories. The success of this venture is reflected by a balance of $6,829.60 after the payment of all expenses. The total receipts were $27,127.93 and the expenditures $20,298.33. To the exhibitors was made a refund of 10 per cent of the cost of their space, $1000 was paid to the technical department and $166.50 to the American Institute of Metals. After all of these payments a comfortable balance remained in the account, sufficient to assure the success of the Boston show without the financial assistance of the technical branch. In this connection the members of this organization may point with pride to the success attained in financing the big undertaking. No money was borrowed, nor was the technical fund drawn upon to defray any of the expense. The Cleveland exhibition financed itself and the surplus was sufficient to guarantee the payment of all obligations that would be incurred in the preliminary work preceding the Boston show.

Change to Incorporated Body

During the year the transition was made from an unincorporated, voluntary association to an incorporated organization. Membership, therefore, is by individual, and not by company

as heretofore, and the entire membership today is on an individual basis.

Appended herewith are the financial statements of Ernst & Ernst, certified public accountants, Cleveland, who audited the books of both the technical and exhibition departments. It will be noted that the exhibition account audit is dated Oct. 31, 1916, when the financial affairs of the Cleveland exhibition were closed and before the payment of refunds to the manufacturers who purchased space at the Cleveland show.

Your secretary-treasurer takes this opportunity to express his warm appreciation and hearty thanks for the aid and support given him throughout the year by President J. P. Pero, the board of directors and his assistants.

Respectfully submitted,

A. O. BACKERT, Secretary-Treasurer.

AUDITOR'S FINANCIAL REPORT OF TECHNICAL DEPARTMENT

Cleveland, Aug. 24, 1917.

MR. A. O. BACKERT,
Secretary-Treasurer, The American Foundrymen's Association, Cleveland.

Dear Sir:

As requested by you, we have audited recorded cash receipts and disbursements of the American Foundrymen's Association, Incorporated, Cleveland, for the year ended June 30, 1917, and submit herewith our report:

Set forth below is a summary of the cash transactions for the period under review:

CASH BALANCE June 30, 1916—as shown by our previous report..........................		$203.72
Transactions for the Year		
RECEIPTS		
As shown in detail exhibit....................	$16,582.60	
DISBURSEMENTS		
As shown in detail exhibit..................	16,191.47	
RECEIPTS IN EXCESS OF DISBURSEMENTS.		391.13
CASH ON DEPOSIT June 30, 1917............		$594.85

Cash on deposit at June 30, 1917, amounting to $594.85, was verified by us by direct correspondence with the depository banks and reconcilement of the balances reported with the balance shown by the books.

We traced all recorded cash receipts for the year ended June 30, 1917, directly into the bank deposits, and found all recorded cash disbursements to be supported by properly signed and cancelled bank checks on file with the following exceptions:

Date	Name	No.	Amt.	Exception
Feb. 12, 1917	J. P. Pero	517	29.35	Not signed by president.
May 21, 1917	Penton Publishing Co.	559	9.84	Not endorsed by payee.

Recorded Cash disbursements were further supported by an examination of invoices, receipts and other supporting data on file.

As part of our work, we checked the cash received for dues, etc., directly to the members' accounts and found that a cash payment to the account of J. E. Stead on July 21, 1916, recorded as $5 in the cash book, had been posted as $10 on his card.

Included in our report are exhibits setting forth membership dues unpaid at June 30, 1917, aggregating $235, and resigned members' dues unpaid at June 30, 1917, aggregating $295, as shown by the books of the association, but we did not correspond with these members to further verify the records.

The following is a summary of inventory of supplies, furniture and fixtures, emblems, unpaid balance due on Exhibition account and balance of the American Foundrymen's Association Cost Work account as submitted to us:

Furniture and fixtures	$ 250.00
Emblems	64.00
Stationery and printing	248.00
Exhibition account	132.57
American Foundrymen's Association Cost Work account	1,237.50
TOTAL	$1,932.07

No liabilities were disclosed by the association's records or reported to us.

Very truly yours,

[Signed] Ernst & Ernst,
Certified Public Accountants.

[SEAL]

CASH RECEIPTS AND DISBURSEMENTS

AMERICAN FOUNDRYMEN'S ASSOCIATION, INC.—Cleveland

For the year ended June 30, 1917

CASH BALANCE June 30, 1916— as shown by our previous report			$203.72
Transactions for the Year			
RECEIPTS			
Dues, subscriptions, etc.	$10,753.70		
Convention	1,320.00		
From sale of emblems	18.00		
Exhibition committee	2,616.03		
A. F. A. share of 1916 exhibition	1,000.00		
Cleveland local committee	134.35		
Special printing	399.41		
Refund of dues in A. S. T. M.	4.00		
Research Fund	337.11		
TOTAL RECEIPTS		$16,582.60	
DISBURSEMENTS			
Administrative salary	$ 2,400.00		
Clerical salaries	1,035.00		
Office expense	352.70		
Printing	4,488.79		
Postage	808.68		
Convention expense, 1916	1,407.16		
Convention expense, 1917	12.50		
Exhibition committee	1,816.03		
Cleveland local committee	134.35		
Committee meeting expense	2,319.36		
Special printing	330.27		
Traveling expense	86.37		
Legal expense	500.00		
Dues in other associations	55.00		
Cost committee expense	228.87		
Membership campaign	198.70		
Exchange	2.69		
Dues and subscriptions overpaid and returned	15.00		
TOTAL DISBURSEMENTS		$16,191.47	
RECEIPTS EXCEED DISBURSEMENTS			391.13
CASH ON DEPOSIT June 30, 1917			$594.85

AUDITOR'S FINANCIAL REPORT OF THE EXHIBITION DEPARTMENT

Chicago, Nov. 10, 1916.

Mr. R. A. Bull,
Chairman Committee on Exhibits,
American Foundrymen's Association, Incorporated,
Granite City, Ill.

Dear Sir:

We have examined the accounts of the American Foundrymen's Association, Incorporated, and the condition of the Association at Oct. 31, 1916, is shown by the following statement, which is subject to the accompanying remarks:

ASSETS

Cash on deposit	$8,490.91
Accounts receivable	514.47
	$9,005.38

LIABILITIES

Accounts payable	$2,175.78
Net worth	
Surplus income	6,829.60
	$9,005.38

The result of the Association's activities from the time of its organization in April, 1916, to Oct. 31, 1916, appears in the attached statements of income and expense.

We examined the records of cash transactions in detail, and verified the balance on hand by correspondence with the Superior Savings & Trust Co., Cleveland. Checks totaling $511.92 had not been presented for payment at Oct. 31, 1916, but the disbursements were covered by vouchers.

Lists of unpaid accounts receivable and payable are attached, but these were not verified by direct communication.

We did not make a detailed examination of the income received from the Cleveland exhibition, as we were informed that this had been checked by the Committee on Exhibits.

We found the records in excellent condition and no adjustment of accounts appeared necessary.

Very truly yours,

[Signed] Ernst & Ernst,
Certified Public Accountants.

[SEAL]

INCOME AND EXPENSE

AMERICAN FOUNDRYMEN'S ASSOCIATION, INCORPORATED,

To October 31, 1916

INCOME			
GUARANTEE			
Received from Chamber of Commerce of Cleveland..		$ 1,000.00	
CLEVELAND EXHIBITION			
Space rentals..............	$20,228.70		
Exhibitor's permits.........	3,825.00		
Gate receipts..............	2,030.25	26,083.95	
INTEREST			
On bank balances..........		43.98	$27,127.93
EXPENSE			
Administration		$ 5,793.30	
Advertising		2,530.88	
Annex		2,686.35	
Badges		434.26	
Booths		2,185.97	
General		40.15	
Insurance		32.65	
Labor		281.39	
Manager's assistant........		720.72	
Printing and stationery.....		1,153.84	
Postage		485.00	
Power		1,734.80	
Registration		200.45	
Secretary's assistant........		60.00	
Signs		240.65	
Telephone and telegraph....		162.70	
Traveling—committee		1,248.68	
Watchmen and janitor......		306.54	20,298.33
BALANCE..........			$ 6,829.60

Steel Castings for Ordnance Construction*

By Major C. M. Wesson, Watertown Arsenal, Watertown, Mass.

I am indeed delighted to have the privilege of addressing you on the subject of steel castings for ordnance construction, and I sincerely hope I shall accomplish two purposes: First, to disabuse the minds of some of you of some misunderstandings that I know exist in them; and second, to be of some assistance to others in the very important matter now with us of producing castings for war material. I purpose to deal principally with plain carbon steel castings, such as can be produced with any commercial installation, using the open-hearth, tropenas converter, bessemer converter or electric furnace, provided proper care is given to details, including finally, a simple heat treatment.

Special heat-treated and alloy-steel castings offer a wide field of endeavor, and our knowledge is rapidly increasing concerning them. The prediction is ventured that eventually they will displace the high-grade intricate forging, just as the plain casting, as we know it today, has in a large measure supplanted the plain forging. We have, however, not time to dwell on them here.

Development of Modern Field Artillery Began in 1900

A brief reference to the situation which resulted in the ordnance department of the army undertaking the manufacture of steel castings, instead of relying on the private manufacturer to produce them, may be of interest. The development of modern field artillery, which today has culminated in the glorious French Seventy-five, your own 3-inch field piece, and the

*Acknowledgment is made to Dr. F. C. Langenburg, metallurgist; R. B. Farquhar, foundry superintendent, and J. M. Sampson, chief melter, for assistance rendered the author.

French Schneider 11-inch howitzer, not to mention the engines of destruction used by our adversaries, began about 1900. This departure in type from the artillery carriage, familiar to you all in the public squares of our towns and villages, necessitated, as will be explained later, steel castings of thin sections, of the best quality that could be produced. The inquiries proved that it was impossible to get such castings in this country, with the exception of one concern in New York state, which at that time was able to produce a small number of them. This situation resulted in great delays, and hampered our ordnance engineers in their development of the early experimental types of carriages. The large steel companies in Pennsylvania which were furnishing ordnance material, refused to undertake the manufacture of the thin-section castings, and even at a date very much later than this, took the stand that they were not able to make a steel casting of the distance ring for traversing rollers. This was at a time when, due to trouble with the forged steel rings, it was very desirable to procure cast steel ones. It is only fair to say in defense of the steel casting makers, that the inquiries for small steel castings were not for large lots; hence, the inducement to take up a new line of product was comparatively small. This condition aggravated the difficulties, and in the public files there is voluminous correspondence relating to the delays caused by inability to procure small castings. Quoting from a paper dated Feb. 19, 1899, the commanding officer of Watertown arsenal reported that "Shot trucks have been completed and issued. They were all completed except the steel trucks some months ago. Steel casting companies will not take small orders at this time." It was not long after this that a small converter plant was established at Watertown arsenal, due to this situation as regards the small thin casting, which plant has been in continuous operation since then. But why castings of this character? Why should the Government ask for an article not demanded by the trade? I dare say the conclusion was reached in various quarters that the specifications were ill-advised, and were the offspring of ignorance and impracticability.

Let us consider for a moment, very briefly, the various classes of gun carriages in use, in the construction of which the large majority of castings under discussion are used.

Gun carriages may be divided into two distinct classes: (1) Carriages for mobile artillery and (2) carriages occupying a permanent or fixed position. It is evident that mobility of gun and mount will necessitate factors in design which are not necessarily considered in a carriage of the second class.

The question is often asked, "Why, for example, is the caliber of a certain gun set at 3 inches or 4.7 inches?" The answer to this is quite simple. The degree of mobility demanded of any piece will depend entirely on its character, being less for heavy siege guns where rapidity of movement is not so essential and greater for field guns which may by necessity have to be moved from place to place with great rapidity, as the progress of an engagement demands.

The power of any tractor or of draft horses must be taken for artillery purposes as less than that which would generally be taken in commercial work. This is due to the fact that on occasions considerable distances might have to be covered at high speeds; and secondly, the roads encountered generally will be inferior.

Given, for example, the power of a tractive force (six-horse team), at 3900 pounds, the problem was to design a gun and carriage of the greatest possible power, with the requisite mobility to meet the tactical requirements of artillery operating in support of field armies. Considerations such as these led to the adoption, in our service, of the 3-inch field gun and, in the French service, of the 75-millimeter gun. Both of the types referred to are direct fire guns; that is, they are designed for firing at relatively small angles of elevation. If the evolution of the horse had resulted in an animal with the strength of an elephant and the speed of a deer, the modern light field gun, instead of being 3 inches in caliber, would probably be many inches greater, with a corresponding increase in power.

There is also provided in our service a howitzer of equal degree of mobility for each gun. The howitzer is a short gun, designed to fire at high angles of elevation, and is utilized for

shelling protected positions or, in other words, employs curved fire to accomplish what direct fire would not do.

On the old type carriage, no provision was made for the recoil of the gun on the carriage. Upon firing such a gun, the carriage would jump to the rear many feet, and before the gun could be again fired, the carriage had to be laboriously returned to its original position, and the gun reaimed. Modern carriages permit of relative motion between the gun and carriage, and are fitted with a recoil system for absorbing the energy of the recoil. After the spade is once firmly embedded in the ground, no motion of the carriage to the rear will occur, and in this way the rapidity of fire is greatly increased.

The modern recoil system consists of a hydraulic recoil brake and counter recoil springs or compressed air, these latter being for the purpose of returning the gun to battery after recoil has occurred. The recoil brake consists of a cylinder filled with oil, in which moves a piston. An aperture having a constant or varying orifice is provided between cylinder and piston, one of which is attached to the gun, and the other to the carriage.

The relative motion of the cylinder and piston when the gun recoils, develops a pressure in the recoil cylinder due to the resistance offered by the liquid passing through the orifice between piston and cylinder. The braking action of such a system is very widely varied by the design, and is always adjusted so that the moment of this resistance with respect to the end of the trail is less than the moment of the weight of the gun and carriage with respect to the same point. This condition prevents the wheels from being lifted from the earth during recoil, and thereby disarranging the laying of the piece.

The recoil system outlined above is also applied to heavy seacoast guns and carriages, and it might be of interest to refer briefly to some of their main features. These mounts may be classified in general as either barbette or disappearing carriages. On the former the gun is always exposed above the parapet, while for the latter it is withdrawn behind the parapet by the force of the recoil after each round. As mobility, and in consequence lightness of construction is not a primary consideration in seacoast carriages, the designer has greater latitude in

weights of materials employed and such mounts can readily be constructed which will absorb the energy of recoil of guns of a much higher power than commonly used for mobile artillery. Guns mounted on barbette carriages are sometimes protected by turrets.

These machines form a group which throw projectiles from 12 pounds to two tons, to a distance of from 6000 to 21,000 yards. The tremendous energy of the recoil must be absorbed by the gun carriage which at the same time stores up a sufficient amount to return the gun to its original position on the carriage. This cycle must be accomplished without resultant disarrangement of the carriage; otherwise, the aim will have been disturbed, and rapid fire accurately placed cannot be delivered, and finally, no part of the carriage must be overstrained. The failure of a single part may, and probably will, put the piece out of the action. The painstaking care in the production of the 999 parts may be vitiated by the indifferent quality of the one part.

The force created by the explosion of the charge which sends a projectile on its way, the reaction from which has to be absorbed by the carriage, is sufficient, if uncontrolled, to demolish the gun, the carriage and the personnel which serve them. Further statement to prove that the ordnance engineer must demand material of good quality, appears unnecessary, except it may be added that considerations of mobility in the field pieces require the least possible weight, which condition reduces the designer's factor of safety to limits far less than is ordinarily permitted in commercial construction.

Physical Requirements

The following table taken from Form 434, "Instructions to Bidders and General Specifications, Etc.," gives the physical properties required of the various materials employed in carriage construction. Particular attention is invited to the three grades of cast steel Nos. 1, 2 and 3:

Metal	Physical Qualities of Metal Elastic Limit Lbs. per sq. in.	Tensile Strength Lbs. per sq. in.	Elongation after Rupture Per cent.	Contraction of Area Per cent.
Cast steel, No. 1..........	25,000	60,000	16.0	24.0
Cast steel No. 2..........	35,000	75,000	15.0	20.0
Cast steel No. 3..........	45,000	85,000	12.0	18.0

Forged steel, No. 0*	.....	.....	...	...
Forged steel, No. 1	27,000	60,000	28.0	40.0
Forged steel No. 2	35,000	75,000	20.0	30.0
Forged steel, No. 3	42,000	90,000	16.0	24.0
Forged steel, A	53,000	93,000	18.0	30.0
Forged steel, B**	65,000	95,000	18.0	30.0
Forged steel, C**	75,000	110,000	14.0	30.0
Forged steel, D**	100,000	120,000	14.0	30.0
Nickel steel, Pl	63,000	100,000	18.0	...
Tool steel, A	75,000	125,000	16.0	35.0
Tool steel, B	95,000	140,000	12.0	20.0
Tire steel	50,000	100,000	17.0	30.0
Flange steel***	40,000	64,000	20.0	45.0
Wrought iron	22,500	50,000	25.0	35.0
Cast iron, No. 1	.....	22,000	...	...
Cast iron, No. 2****	.....	28,000	...	...
Bronze, No. 1	.....	28,000	...	...
Bronze, No. 2	.....	35,000	...	...
Bronze, No. 3	.....	45,000	...	...
Bronze, No. 4	.....	60,000	20.0	...
Extruded bronze	.....	50,000	12.0	...
Instrument bronze	.....	38,000	...	...
Tobin bronze	.....	52,000	30.0	...
Copper	.....	32,000	22.0	...

*No Physical test.

**Nickel alloy steels.

***Physical requirements of commercial flange steel not indicated here.

****Cast iron, No. 2, must not show a tensile strength of more than 39,000 pounds per square inch.

No. 1 castings are of very mild steel in which the presence of blowholes may be permitted when, in the inspector's judgment, they are not serious enough to affect the value of the casting for the purpose intended. Little trouble is encountered in manufacturing castings of this grade as the ductility requirements, 16 per cent elongation and 24 per cent contraction, are exceedingly reasonable. Cast steel No. 1 is used only on unimportant parts where the allowable section permits the use of a material having a low elastic limit.

Cast steel No. 2 with 35,000 pounds elastic limit, 75,000 pounds tensile strength, 15 per cent elongation and 20 per cent contraction is a better grade than No. 1, and must be free from blowholes. The American Society for Testing Materials on a grade of steel known as "Class B, hard", calls for 36,000 pounds elastic limit, 80,000 pounds tensile strength, 15 per cent elongation and 20 per cent contraction.

The society quoted above expects a higher elastic limit and tensile strength, as will be noted, for a given ductility than is demanded by the U. S. Army. Attention is invited to this fact as there seems to be an opinion in some quarters that the ordnance specifications, U. S. A., are unreasonable.

Cast steel No. 3, 45,000 pounds elastic limit, 85,000 pounds tensile strength, 12 per cent elongation and 18 per cent contraction is a similar grade to No. 2, with the exception that the elastic limit and tensile strength have been increased and the ductility lowered. Both grades, Nos. 2 and 3, are used for important castings demanding good physical properties.

Proper design will limit the use of No. 3 to parts where the allowable section is limited and the stresses which must be endured demand the use of a material having a high elastic limit.

It is considered advisable to use No. 2 in preference to No. 3 for all members which can be made of such cross section that will allow of the use of a material having an elastic limit of 35,000 pounds.

Cast steel No. 3 is produced by a higher carbon content than is required for No. 2, and the heat treatment is in general different, as will be explained later.

As to composition, the only limitation imposed by the specifications, is that the phosphorus shall not exceed 0.05 per cent and the sulphur 0.07 per cent. Even under present conditions, there is no difficulty in complying with these requirements which are reasonable, less exacting than demanded by A. S. T. M., or the specifications for American railways, and are being met daily at your Government arsenal at Watertown, Mass.

I desire to emphasize this point, as some casting makers recently have declined to produce castings for the Government, on the grounds of the unreasonableness of the chemical specifications. *The Iron Trade Review* in an editorial on July 12 expressed its opinion on this question in connection with another subject. I may say here that I have been informed that issue has been taken with them on that editorial, and (August 22) I await its appearance in that estimable journal.

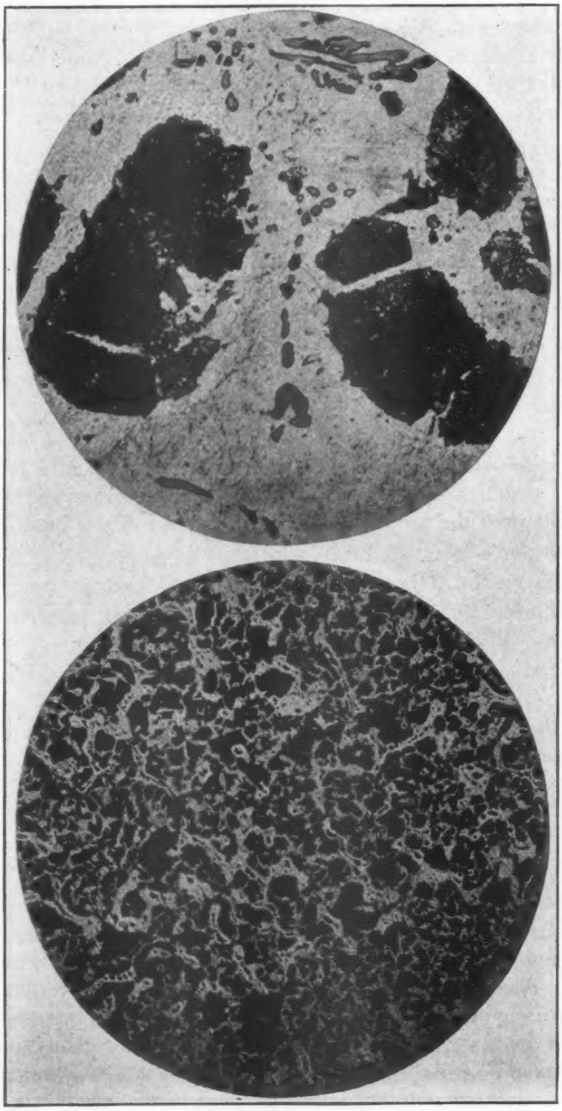


FIG. 1—MICROSTRUCTURE OF NO. 3 CAST STEEL DEFICIENT IN DUCTILITY

At the left, 50 diameters; at the right, 500 diameters. Carbon, 0.42 per cent; manganese, 0.72 per cent. Yield point, 52,500 pounds per square inch; tensile strength, 85,500 pounds per square inch; elongation, 9.5 per cent; contraction, 9.5 per cent

The endeavor thus far brings us to the conclusion of the first part of our topic, which is, to bring out that the specifications for Government castings are reasonable, and not more difficult to meet than the requirements on which commercial engineering practice is based, and further that there are sufficient and proper reasons for exacting the reasonable qualities prescribed for them.

Hard to Get Satisfactory Small Castings

I previously referred to the earlier difficulties in procuring steel castings some 17 years ago. Today the situation as regards the larger castings of the lower grades is satisfactory, but as regards the small higher grade castings, it is still far below what it should be. The Rock Island arsenal and the large private ordnance manufacturers have been having great difficulties in securing satisfactory small castings. I learned recently that a number of large howitzer carriages, which are being manufactured by a large private corporation, have been greatly delayed in completion, because two separate sub-contracts, which it placed for the small castings involved, had been cancelled on account of failure to deliver them.

In connection with this subject, I quote from an official letter of recent date as follows:

"A reply to preceding endorsement has been delayed with a view to determining what success we would have in obtaining steel castings on existing contracts placed with steel casting manufacturers. * * * The results, except for cast steel No. 1, are very discouraging. Practically all of them make 'steel castings', generally without regard to physical qualities. Cast steel No. 3 and No. 2 are almost beyond their ability. Many of them with whom the subject has been taken up knew nothing about physical qualities. We had expected to obtain satisfactory results from the * * * but they are having much trouble with a large order for steel castings No. 3. It is apparently due to their inability to obtain coke with a low sulphur content." As regards this question of sulphur, I personally believe that if the sulphur difficulties are not sufficient to prevent the production of the No. 2 grade, there should be no reason why the No. 3 grade could not be made.

Satisfactory small steel castings of both the No. 2 and No. 3 grade can be made, and by any of you who possess ordinary foundry equipment, if you will take the precautions to procure suitable material, and exercise the proper care as to details. These latter extend not only to the production of the metal itself, but include the essential items of mold treatment, molding sand, gates, risers, etc. The best metal that can be produced will result in porous or cracked castings, if the mold which receives it does not measure up to certain requirements. This problem of the mold you are meeting every day in castings demanded for the motor-car industry, and others where intricacy of pattern equals, or is greater than that encountered in ordnance work.

Practice at Watertown

I have outlined below the basic features on which the practice at your arsenal at Watertown rests. No claim is made to originality. The practice outlined is believed to represent good practice. Unquestionably, there is large room for improvement. Many of you will probably not benefit by this description; others, I believe can profit by it. This belief is being based on the fact that the Watertown arsenal (August 22), during the preceding six weeks has had inquiries from eight casting makers as regards matters of steel practice, to obtain satisfactory results. There have been personal interviews with representatives from four or five of these concerns.

The equipment of the foundry at Watertown Arsenal may be sub-divided under the following headings: (1) Molding, (2) drying, (3) melting, (4) annealing, and (5) cleaning.

Mold Equipment

The molding equipment consists of one (1) jar squeezer for brass work, 22 x 26-inch table, 36 inches between supports; one (1) 6 x 4-foot jolt machine; one (1) 3 x 3-foot jolt machine; and one (1) 18 x 24-inch jolt machine.

These machines are used for jolting dry or green sand steel work, small and medium in weight, also the small jolt is used for jolting snap-flask work, often with two (2) flasks on one (1) board. Heavy air rammers and light bench air rammers are largely used by the molders and are popular.

The drying equipment consists of one mold oven, 24 x 19 x 9 feet high; one mold oven, 22 x 15 x 10 feet high; one core and snap flask mold oven, 20 x 9½ x 10 feet high and one core oven, 18 x 6 x 10 feet high. The latter is served by two narrow gage cars, the oven opening at both ends and the cars entering one end from the core room and discharging from the opposite end into the foundry.

Melting Equipment

The melting equipment consists of one 15-ton tilting open-hearth furnace, oil-fired. This furnace can easily melt fifteen (15) heats per week of acid steel, using low-phosphorus stocks and steel scrap. It is served by thirty 3000-pound charging buggies on narrow gage tracks. All stock is elevated with a 3-ton electric hoist from flat cars. The charging is done by hand, assisted by two 1000-pound air hoists.

Converter

The converter equipment consists of a 2½-ton side-blow Tropenas converter with Root blower, motor driven, the blower equipment being in duplicate and one 42-inch cupola with charging platform 15 feet above the foundry floor. The charging platform is served by a 10-ton elevator.

The equipment for melting alloy additions for the converter metal consists of drip-pan, oil-fired furnaces, served with chain hoists and overhead telpher. The ladle equipment consists of two 20-ton open-hearth ladles, bottom pour, and the usual number of top-pour worm-gear foundry ladles, from 5 tons capacity down; also one 2-ton bottom pour ladle for handling iron and steel from the converter. The ladles are heated by top fired combustion chamber ladle heaters.

In addition to the foregoing there are five (5) coke-fired individual pot brass furnaces, taking pots up to No. 300.

The melting and molding bay is approximately 48 x 300 feet and is served by one 10-ton crane; one 20-ton crane with two 10-ton trolleys, and one 30-ton crane with two 15-ton hoists.

Annealing

The annealing equipment consists of two car bottom furnaces which are described in more detail later.

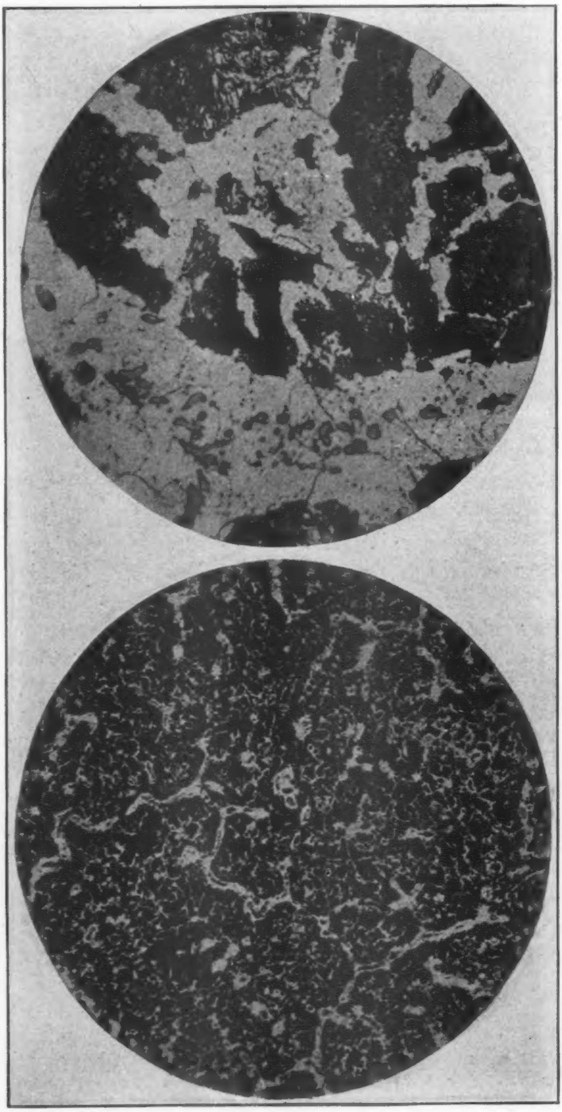


FIG. 2—MICROSTRUCTURE OF ANOTHER SPECIMEN DEFICIENT IN DUCTILITY

At the left, 50 diameters; at the right, 500 diameters. Carbon, 0.43 per cent; manganese, 0.72 per cent. Yield point, 51,500 pounds per square inch; tensile strength, 86,500 pounds per square inch; elongation, 7.5 per cent; contraction, 13.3 per cent

The chipping and cleaning shop is served by one 5-ton electric hoist; two 3-ton electric hoists; one 5-ton jib crane and additional chain hoists; three oxy-acetylene cutters and welders; one high-pressure two-nozzle air blast, the room being large enough for two 5-foot square buggies; one 8-foot sand mill; three cold saws; one two-wheel stationary grinder; and two cold saws for bronze work. Several types of air hammers are used.

Nature of Work

Castings to meet the various grades specified above, or special grades of alloy steel castings when so specified, are produced in weights from a few ounces to 15,000 and 18,000 pounds each. Many of the castings are made from individual patterns, the orders for castings from each pattern usually not exceeding 100, many times not exceeding 10 to 20. Many of the sections of the smaller castings being very light and the design intricate, necessitates complicated core work and careful molding. Releasing to prevent hot checks and cracks is often necessary. Many of the heavier castings weighing from 2000 to 5000 pounds are bulky and of easy sections, some sections being 6 to 8 inches thick. Some of the heavier castings have large lightening cores and thinner sections as low as 1 inch in thickness, and hence are difficult to produce. It will thus be seen that there is a great variety of castings being produced.

Molding

Nearly all of the work is made in dry sand, using various mixtures of silica sand, silica rock, heap sand, clay and molasses water. The mixtures are transferred to the molding floor in wooden boxes. These mixtures are worked out by the superintendent and the foreman according to the nature of the work, and are varied from time to time according to the available materials. A large percentage of ground silica rock has always been used by the Arsenal foundry, and while its cost has been considerably greater than the cost of an equivalent amount of 98 per cent pure silica sand, the results have been so satisfactory that its use has been considered well justified. There has been an unusual lack of the most common foundry troubles, such as scabs, drops, washes, crushers, broken

cores, etc., and the cost of cleaning and chipping off of burned sand adhering to the castings has been found to be quite low. The use of old heap sand in the mixture of stronger facings has been kept down to a minimum, and while its use might possibly be increased in some cases, any great increase would probably show a corresponding increase in expense of cleaning and losses due to defective castings.

Green Sand

Due to the fact that virtually all of the Arsenal castings are subject to specifications to meet difficult service, and many of them are machined all over and practically all of them machined in part, it has been found difficult to satisfactorily produce much of such work in green sand. Occasionally, the percentage of work made in green sand can be increased.

Relative Amount of Hand and Machine Work

There is no jar-squeeze work done. There is a small amount of straight jolt work done on the small jolt machines, using snap flasks; all such work being dried. There is a considerable amount of small and intermediate work from individual patterns made on straight jolt machines and these are butted off with hand air rammers. Probably not over 15 per cent of the man hours of the shop are applied on molding machine work.

Method of Gating

Whenever possible, castings are gated and poured from the bottom and the usual foundry rules in this respect are followed as to the size of gates to give proper speed of pouring, etc.

Location of Risers

The location of risers has been worked out in the superintendent's office, in conjunction with the foremen of the pattern shop and a riser boss. Correct risers have been provided by the pattern shop before the patterns are delivered to the foundry. This makes it possible to be assured that risers of the correct size will be properly located by the molders, even though a new molder may get a pattern with which he is not

familiar. Previous practice which has been found satisfactory is thus transmitted automatically to the shop and adhered to. A common rule of keeping the height of riser approximately 1½ times its diameter has usually been found satisfactory. The percentage of riser necessary, naturally varies from almost nothing in some of the very light castings which do not require much feeding to 25 and 30 per cent in the heavier castings which may not solidify for two or three hours after pouring.

The majority of the converter blows are poured into steel castings. All of the small intricate-section snap flask castings are poured from the converter. Many of the medium and fairly heavy castings are likewise poured from the converter metal or from the open-hearth metal alternately, depending upon the desirability at the time. For example, on many of the smaller castings weighing as low as 400 or 500 pounds, which have thick sections and can easily be run with open-hearth metal, it has been found desirable to pour from the open hearth, because the metal is cheaper and slightly more uniform in chemical composition and meets the physical requirements more regularly.

On the contrary, many heavy castings that it would be desirable to pour from the open hearth (castings weighing up to 4000 pounds) may occasionally be poured from the converter metal as would be the case if the converter is running when the mold is ready and the open hearth is not ready or is on an ingot heat. The flasks are thus released and the production kept up although at a slight increase in the actual cost of the molten metal. On all the more important and heavier castings, at least two (2) coupons are cast on the body of the casting. For the less important and lighter castings, either from the converter or the open hearth, two (2) standard test coupons are cast from a single runner. These coupons are approximately 1½ inches at the bottom, tapered to 2 inches for a height of 5 inches and are 6 inches long. These test pieces are poured at about from the middle of the ladle. All test pieces and all castings are stamped cold with heat number and a serial casting number for identification during the manufacture and for record. All ingots, shell or otherwise, are tagged on top by the insertion, while in molten state, of a sheet steel strap stamped with heat

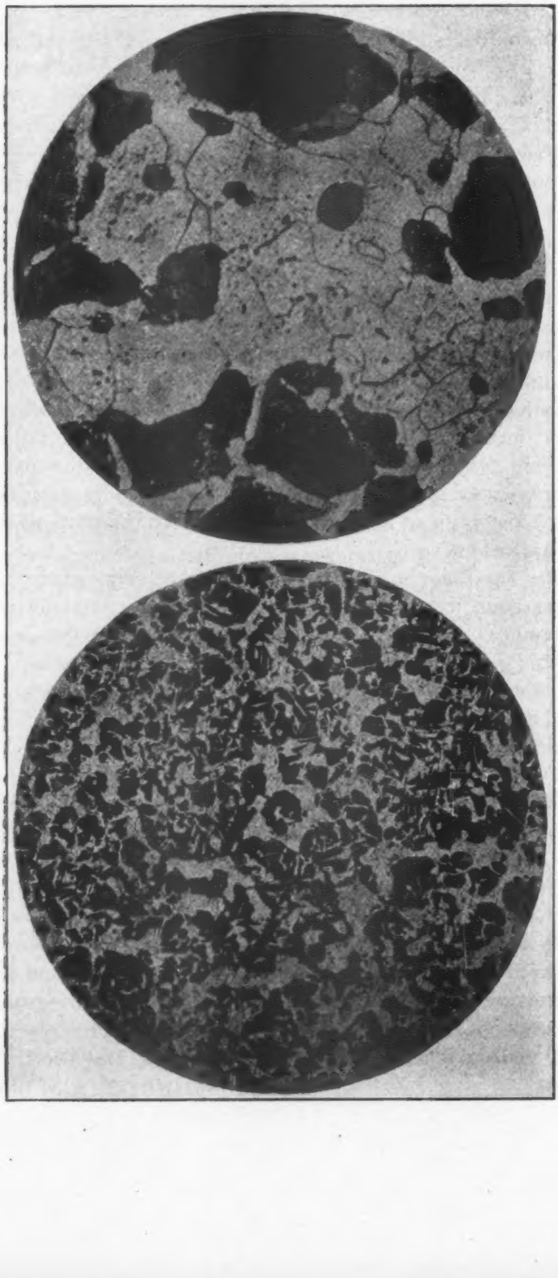


FIG. 3—MICROSTRUCTURE OF SATISFACTORY SPECIMEN

At the left, 50 diameters; at the right, 500 diameters. Carbon, 0.426 per cent; manganese, 0.52 per cent. Yield point, 45,400 pounds per square inch; tensile strength, 85,300 pounds per square inch; elongation, 18.0 per cent; contraction, 23.2 per cent

number, serial number of ingot and code number of the grade of steel.

A 2½-ton drop-bottom Tropenas converter is used, lined with silica brick next to the shell up to the tuyere blocks, the balance of the lining being a ganister mixture, composed of 18 parts of ganister, six parts of silica sand and four parts red clay, bone dry.

One-half of the rock is first put in the sand mill and, after partial grinding (15 minutes) one-half of the clay is added, all of the sand, the balance of the clay and rock in the order named. When sufficiently ground and mixed, it is wet down with thick molasses and water. The mixture is made only as needed as it is found that the results are not satisfactory after the mixture has stood too long. This mixture is used for patching, care being taken not to put the patch over adhering slag. In case of a shallow patch, which might otherwise spall off, a few large nails are inserted into the old lining to assist in holding the patch in place. Before putting on patch, the spot is daubed with thick molasses and also swabbed over with the same material when the patching is completed. Seven (7) brick tuyeres are used. It is very important that the tuyere holes (not tuyere bricks) should always be used in the same horizontal plane when the converter is set plumb. The inside capacity of the vessel and the charge should be regulated in such a way that when blowing, the converter will be set at an angle of about 5 to 7 degrees, in no case more than 12 degrees.

Operation

Steel is blown on alternate days, running 8 to 12 blows per day, depending upon the tonnage on the floor to be poured. It is very essential to have ladle and converter thoroughly preheated before starting the first blow. The procedure in the case of the converter is as follows: At 4:30 a. m. the converter is filled with coke to well above the tuyeres and lighted up. From 5:30 to 6:00 the blast is put on, using about 1½-pound pressure. A grating is then put over the nose on the vessel and the converter burned upside down until 6:30. It is then turned up again and the blast put on for another half hour. This process is repeated with coke always well above

the tuyere hole, until the vessel shell is approximately the temperature of boiling water. This will usually be between 8:00 and 8:15 a. m.

The pig iron used is high-silicon bessemer of the following specifications: Manganese not to exceed 1 per cent (generally runs about 0.15 per cent); sulphur and phosphorus not to exceed 0.035 per cent; silicon, 2.75 to 3.25 per cent, and copper not to exceed 0.75 per cent.

Crop ends are used, being purchased on same specifications as for the open hearth. From time to time, a car is picked out which contains a large percentage of pieces of the right size. Normally, gates and risers from castings are used, but if the open hearth is in operation it consumes all of this class of material, and the steel scrap portion of the converter charge is made up of low-sulphur and phosphorus crops, thus always keeping the sulphur well below the limit. The ferrosilicon used is the standard 50 per cent, ferromanganese 80 per cent, and ferrotitanium 15 to 18 per cent.

Cupola

The cupola is 42 inches in diameter with six 7 x 12-inch tuyeres set 16 inches above the sand bottom, the charging door being 110 inches above the tuyeres. Twenty-two hundred cubic feet of air per minute are used, bringing down 5700 pounds of iron about every half hour. The full charge is 5700 pounds, charged in 1425 pounds at a time. The cupola mixture will run from 40 to 45 per cent steel scrap with a coke ratio of about one to seven. By-product coke is used which is low in sulphur and ash, a typical analysis being about 0.53 per cent sulphur and 7.75 per cent ash. Ordinarily, about 20 pounds of lime rock are added to every 5700 pounds charge. This may vary, however, according to the amount of sand adhering to the pig and scrap. In case sulphur is running above the limit desired, 15 to 20 pounds of fine ferromanganese is used in the spout when tapping the cupola or lump ferro is charged in the cupola.

The cupola charge is adjusted so as to give approximately 1.90 per cent silicon; this amount of silicon is sufficient to give a very hot steel. On account of using a high percentage of

steel scrap in the cupola charge, the percentage of carbon is cut down in the cupola metal, thereby shortening the blow in the converter. The theory which is also borne out by practice is that silicon will give the requisite amount of heat units by its combustion, whereas the combustion of the carbon, which results in the formation of carbon monoxide, gives off very little heat, barely sufficient to counteract the chilling effect of the nitrogen introduced with the blast and the radiation and conduction losses.

In blowing, a pressure of 4½ to 5½ pounds is maintained. The carbon flame is obtained usually about two to three minutes after the beginning of the blow, the total time per blow being 16 to 17 minutes.

Sometimes, due to carelessness upon the part of some of the men, the ladle and converter will not be hot enough for the first blow, and this will be indicated by the appearance of the flame. The judicious use of 50 per cent ferrosilicon at this stage will usually overcome the difficulty, which, however, should not be encountered.

Additions to Converter Metal

The service demands the use of four (4) ladles, one for the cupola, one to receive the weighed charge of molten cupola iron, transferring it to converter, and two (2) ladles used for pouring the castings. They are all lip-poured ladles, operated with worm-gearing, a bottom poured ladle being occasionally used for particular work. While one heat is being poured in the molds, the other casting ladle with the necessary amounts of ferromanganese, ferrosilicon and ferrotitanium in the bottom is being preheated under an oil-fired ladle heater.

About two minutes before the finish of the blow, the ladle is lowered on the platform scale, tared, and scale weights set for necessary addition of molten cupola iron used for recarbonizing. This amount of cupola metal for recarbonizing will vary according to the size of the charge entering the converter, the calculated losses in the converter and the desired final carbon. It is found that, ordinarily, one can estimate the losses in the converter quite closely, and thus vary the amount of cupola metal accordingly, but in cases of doubt, it is the prac-

tice to weigh the blown metal poured into the molten cupola iron. The regular practice, however, is as follows: After the necessary cupola metal has been added to the ladle, the crane swings this ladle over to the converter and the blown metal is emptied into the ladle. As soon as the vessel is turned down at the end of the blow, the vesselman throws a couple of shovels full of dry sand on top of the slag in the vessel and then throws a brick on top of the slag just inside the nose of the vessel. When pouring the blown metal from the vessel into the ladle, the vesselman, by means of a long bar or rod resting on this brick, retains nearly all of the slag in the vessel, which slag is removed by turning the vessel upside down as soon as the ladle is swung out of the pit. The casting ladle is taken to the skimming floor, and there, by means of bent hooks, the small amount of slag is removed from the top of the steel. The steel should be hot enough at this stage to be able to hold it at least 10 minutes before starting to pour. Just before starting to pour the first mold, the thin film of slag adjacent to the lip is skimmed back, and a hot brick dropped on top of the steel, next to the lip. When pouring into the molds, a man keeps this skimming brick in place (close to the ladle lip), in this way effectually holding back the remaining blanket of slag.

In concluding the remarks concerning the converter practice, it may be well to emphasize a few points which may possibly not have been duly accentuated above:

1.—Careful selection and grading of melting stocks.
2.—Small cupola charges, thus obtaining uniform melting practice and uniform iron.
3.—Sufficient preheating of ladles and converter.
4.—Hot, quick blows.
5.—Careful skimming in converter and ladle.
6.—Holding the steel in the ladle at least 10 minutes prior to pouring.
7.—The most important requisite of all, hot steel.

Open Hearth

The open-hearth furnace used is, as previously stated, a 15-ton tilting furnace especially adapted for burning oil. It has but one set of checker chambers and one reversing valve. The size of the hearth is 20 x 9 feet.

The common practice in making the acid bottom is departed from somewhat inasmuch as an average of only four (4) to six

(6) inches of bottoming sand is used. The remainder of the bottom and banks is built up of silica brick, with careful allowance made in the laying for expansion of each successive course. It is found that by making the bottom in this manner, much less trouble is experienced due to corrosive action of the slag or from excessive rust on steel scrap.

The purchased materials used in making up the open-hearth charges include pig iron with silicon, 1.50 to 2.25 per cent; manganese, maximum, 1.50 per cent; sulphur and phosphorus, not over 0.035 per cent. Plate scrap and crop ends of suitable size and shape with sulphur and phosphorus not over 0.04 per cent also are employed. An important reason for the low-sulphur specifications in case of crop ends, is because this material is used in the cupola charge for converter steel, as previously described. Other materials used are shop scrap; risers; gates, etc.; ferrosilicon, ordinary 50 per cent grade; ferromanganese, 80 per cent grade; ferrotitanium, 15 to 18 per cent titanium content, 5 to 8 per cent carbon content; aluminum, the best grade and also No. 2 aluminum running 94 to 96 per cent. The following is a typical charge: Pig iron, 7000 pounds; shop scrap, 10,000 pounds; plate scrap, 5000 pounds; crop ends, 14,000 pounds. This will give a charge of approximately the following composition: Carbon, 1 per cent; manganese, 0.69 per cent; silicon, 0.60 per cent.

Order of Charging

First pig iron, next plate scrap and third heavy scrap are charged in the order named. A sufficient interval is allowed between charging the plate scrap and heavy scrap to permit the plate to soften under the heat and sag down in the furnace. It is then covered with one to 1½ barrows of bottoming sand to counteract the consequences from the rust, which results in excessive corrosive action on the banks.

A good flame during charging is maintained and to completely melt requires about 4½ hours from the time charging is begun. The furnace is charged by hand. requiring about seven (7) men, besides the first helper. The time consumed averages about 1½ to 2 hours. From the time charging is begun until

the heat is tapped averages almost six hours. The carbon in the bath, when charge is melted, will average 0.65 per cent, thus giving from 28 to 30 points of carbon to work on before adding the finals. It is attempted to adjust the flame and slag so as to eliminate one point of carbon in about three minutes. The use of iron ore in the bath to reduce carbon, after the carbon is below 0.55 per cent, is avoided if possible. In case the bath is lying too quiet and carbon not dropping fast enough, 100 to 200 pounds of crop ends are thrown in without increasing the basicity of the slag. The condition of the slag in the furnace and its character when poured into test molds for fracture tests are carefully observed. If it has the least indication of wildness and especially if the end of the heat is near, it is adjusted effectively by the addition of bottoming sand and a little loam, otherwise "blowy" castings will be the consequence.

The latter part of the refining operation is done entirely by heat, making the steel very hot and the slag as gray as possi-

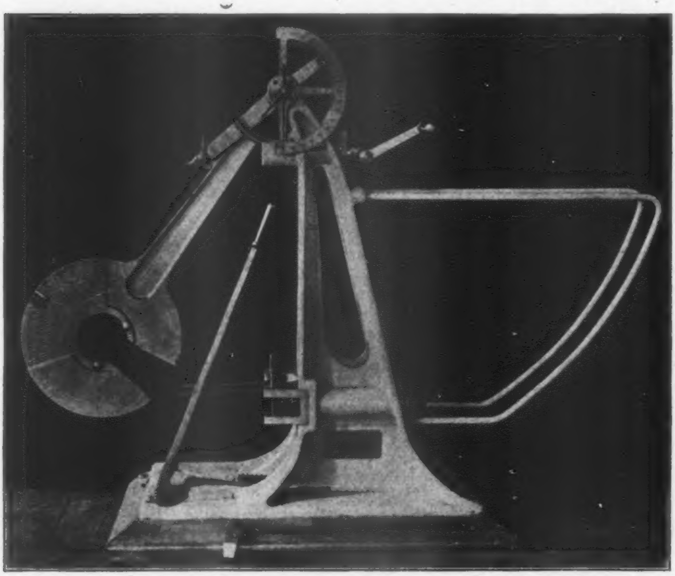


FIG. 4—CHARPY IMPACT MACHINE, SIDE VIEW

ble, with a reduction of some of the silica in the slag to silicon. This reduction of silica will have to be estimated by the appearance of the test specimen and when the steel is hot enough and the carbon at about 0.38 per cent there is introduced enough ferrosilicon to give about 0.25 to 0.30 per cent silicon, the gas and air are shut off and damper lowered until carbon report is received from chemical laboratory. The ferromanganese is then added, stirring it through the bath as quickly as possible, and in from three to four minutes the heat is tapped out.

A pouring cup and runner large enough to take a full stream of metal without choking back is used in pouring all castings. Risers and gate openings are kept closed until just before pouring to prevent any dirt or foreign matter finding its way into the mold.

In making No. 3 cast steel, the attempt is made to tap at about 0.38 per cent carbon which, with the carbon taken up from the ferromanganese addition, will give a final carbon of 0.43 per cent in the heat. In other words, it is endeavored to catch carbons coming down, making due allowance for carbon increment from the ferroalloy additions.

Additions

In adding the finals there is used a variable amount of ferrosilicon, 350 pounds of ferromanganese, and 90 to 100 pounds of ferrotitanium. Sometimes a portion of ferrotitanium is replaced by aluminum. These are added to the ladle during tapping out. In tapping a heat, pieces of sacks or a piece of wood block is held in the tap hole sufficiently long for the metal bath to entirely include the tap hole, thus preventing the slag from running out in advance of the steel.

Great care is used in making up stoppers and adjusting the stopper in the ladle. A nozzle is used that is double burned and very true to shape and of a size recommended by the American Foundrymen's association for the 2-inch round faced nozzle. A standard grade of graphite stopper head is used, suitable for this nozzle. The stopper-head is

keyed to the stopper-rod, being keyed up snugly and then released just a little. The stopper rod is 1¾ inches in diameter, made up with 2-inch sleeves.

Annealing

The paragraphs in the specifications governing the annealing of castings are as follows:

"All castings shall be heated at least once to a temperature not less than 30 degrees Cent. above the AC_3 point. If the castings are then allowed to cool in the furnace, no reheating shall be necessary, but if they are drawn from the furnace and air chilled they shall be reheated to a suitable temperature. Rapid cooling as in oil or water will not be permitted without special authority.

"All forgings and castings shall be heated for annealing, drawing, or other heat treatment as required as evenly as possible, and the operation shall be performed on the whole of a piece, never on a part only. During any annealing, drawing, or other heat-treating process, steel pieces should be held at the desired temperature for a sufficient length of time to insure that the heaviest part of the piece shall be thoroughly soaked at this temperature."

The furnaces employed at Watertown arsenal consist of one car bottom annealing furnace, 25 x 16 x 7 feet, with track at foundry-floor level. This unit is fired from the side into a combustion chamber, with four high-pressure oil burners; the second furnace, 15 x 7 feet 10 inches x 8 feet, is also of the car-bottom type, the tracks being in a pit bringing the car bottom to the foundry level. This furnace is also fired from the side into a combustion chamber and is equipped with two high-pressure oil burners.

Temperature control is maintained with platinum couples which are connected to Leeds & Northrup recorders. The couples and recorders are carefully checked each week and an accuracy of 5 degrees Cent. is maintained.

The standard annealing treatment for No. 3 steel is as follows: Heating to 950 degrees Cent., holding for four hours followed by air chilling. After the completion of the chill the castings are drawn at 500 degrees Cent. This subsequent draw is considered very essential to relieve any in-

ternal strains which might be present. This temperature, 500 degrees Cent., is not high enough, however, to produce any appreciable readjustment of structure.

All No. 2 castings are annealed by heating to 900 degrees Cent., holding at this temperature for four hours, followed by furnace cooling. The work is very frequently going through the foundry in such a manner that it is not feasible to separate the No. 3 and No. 2 for the annealing operation. In this case, No. 2 is given the No. 3 treatment, namely, the air chill and draw.

The specifications state that rapid cooling such as water or oil will not be permitted without special authority. This clause appears to be justifiable. To allow promiscuous quenching operations to be carried out on all classes of work without knowing the equipment of the contracting parties might lead to serious trouble. Coupons representing small work might be satisfactorily quenched whereas the castings represented thereby might not be quenched in a satisfactory manner. Furthermore, the dangers of cracking are always present and it would seem essential for the government to know not only the facilities but also the experience of the contractor in conducting this class of treatment before permission could be granted to heat treat in this manner.

The principal special treatment which is sometimes employed at Watertown arsenal consists in a prolonged anneal, six to eight hours on small sections, just above the AC_3 point; this treatment has often been successful in improving the ductility of heats which have been given the standard No. 2 or No. 3 treatment. In fact, it is never used unless the standard treatment has failed to produce the desired results and in accordance with specifications, could not be given unless the castings had previously been annealed at a higher temperature.

Recourse is also had at times, in the case of some alloy castings, to a treatment similar to the standard No. 3. The first operation consists of an air chill from 1050 degrees Cent. followed by a draw at approximately 775 degrees Cent.

In certain exceptional cases either water or oil quenching from temperature ranging from 800 degrees to 900 de-

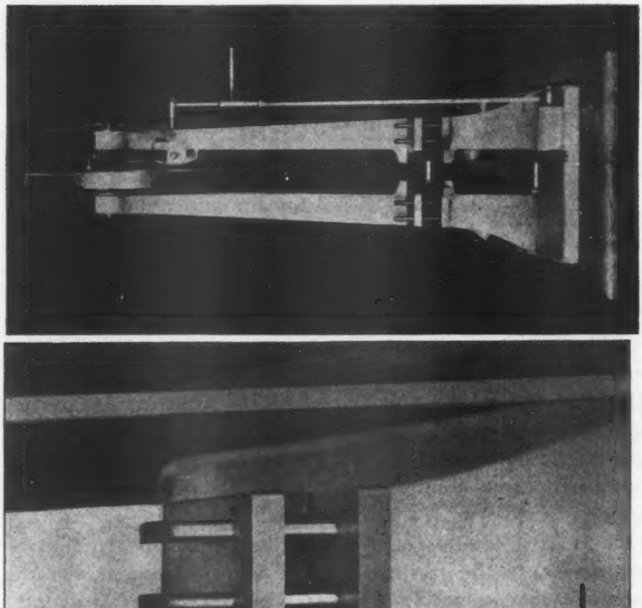


FIG. 5—END VIEWS OF CHARPY MACHINE WITH SPECIMEN IN PLACE FOR TESTING

grees, followed by drawing, at temperatures from 600 to 700 degrees, has been resorted to.

The following figures taken from the results of tests on heats cast in April, May or June may be of some interest:

Month.	No. of casting heats converter.	Per cent. passing 1st test	No. of heats cast O. H.	Per cent. passing 1st test.
April	32	86	8	87½
May	50	60	11	90
June	55	80	10	80

The per cent of heats passing the first test in May from the converter steel was lower than usual. This was due to the fact that a number of alloy steel heats were made which did not comply with the specifications after the first treatment. This specification was 55,000 pounds elastic limit, 90,000 pounds tensile strength, 15 per cent elongation and 25 per cent contraction.

In compiling the above table only those heats, all the castings of which passed the first test, were counted. If a second test was necessary, although due to a defective first specimen, the heat was considered as not passing the first test.

When a heat fails to pass the first test it is the duty of the laboratory to check the chemical analysis, make a microscopic examination of the specimens which failed and then recommend a second treatment. If, for example, the first test showed the following results: 48,000 pounds elastic limit; 90,000 pounds tensile strength; 11 per cent elongation and 14.5 per cent contraction; the second treatment would probably consist of a long anneal just above the critical range followed by furnace cooling. If the low ductility previously mentioned was due to too high carbon, which can easily be determined by laboratory examination, the second treatment would in all probability reduce the elastic limit and tensile strength increasing at the same time the ductility.

If the elastic limit and tensile strength were low on the first test while the ductility was high, the heat would probably be again air chilled but additional care taken in ar-

ranging the castings on the car so as to insure their receiving a good circulation of air when pulled from the furnace.

In meeting the prescribed physical requirements, one particular type of difficulty is often encountered to which special emphasis should be given. The following illustrations will bring out this point: Fig. 1 shows the microstructure of a specimen of cast steel at 50 and 500 diameters, respectively. This material represents the attempt of a commercial foundry to meet the Government specifications for cast steel No. 3. It will be noted that this material is deficient in ductility.

Attention is also invited to Fig. 2. Here again the chemical composition, elastic limit and tensile strength are satisfactory but the elongation and contraction are very poor.

Fig. 3 shows a specimen which was entirely satisfactory.

The explanation of the difference in behavior of these different heats under test is quite simple but it is beyond the scope of present methods in chemical analysis. Microscopic examination shows that both the heats failing in ductility are contaminated with a great deal of slag.

Attention is again invited to Figs. 1 and 2. The micrographs at 500 diameters show an almost complete slag network which surrounded the original austentite grains. This network is very effective in preventing the development of proper structure by annealing and, furthermore. produces decided cold shortness and lack of ductility.

The specimen shown on Fig. 3, although far from being as free from slag as might be desired, shows a much better structure. A continuous slag network is absent and hence the better ductility.

The specimens shown on Figs. 1 and 2 were undoubtedly. poured from cold steel. The slag particles present in the bath at the conclusion of the blow were effectively trapped. This, as mentioned above, is due to cold metal, the slag particles not having opportunity by virtue of their specific gravity to rise to the surface.

Fig. 3 shows a specimen having a decidedly better structure with regard to slag. This test was poured from a

hotter blow than either Fig. 1 or Fig. 2. The slag particles have coalesced and the network is destroyed. If this metal had been still hotter, these coalesced particles would not have been trapped.

Although the foregoing may be regarded as a hypothesis having no place in an ordinary steel foundry, it is felt that enough evidence has been gathered to remove it from the realms of theory to the domain of facts.

It might be well before passing from this portion of the discussion to state that when a specimen fails to pass the requirements of ductility and has a structure similar to Figs. 1 and 2, further annealing treatment is considered useless. The trouble is cold metal. Annealing medicine cannot cure such a disorder and the patient is doomed.

The following tables are indicative of the results obtained from the practice previously described. The first shows a number of converter heats taken in sequence during the month of June and shows the chemical composition together with physical tests. The second table gives the results obtained on 40 open-hearth casting heats taken in sequence.

The tests incorporated in these tables would seem sufficient to refute any statement to the effect that No. 3 cast steel properties cannot be met with considerable certainty and regularity.

The higher sulphurs on heats 5402 and 5412 are due to the careless omission of ferromanganese in the cupola by the operator. The immediate improvement shown in the subsequent analysis was effected by its resumption.

The tables are shown on pages 96 and 97.

CONVERTER HEATS

Heat No.	E.L.	T.S.	Elong.	Cont.	Brinell	C.	Mn.	Si.	S.	P.
5402	48000	90500	19.0	27.4	171	.47	.77	.15	.064	.041
5405	44500	85500	21.5	24.0	156	.40	.82	.212	.068	.037
5406	54500	98500	15.0	20.5	197	.40	.78	.231	.071	.034
5407	49500	91000	17.5	20.5	179	.41	.76	.212	.075	.041
5408	44500	89000	24.5	40.3	171	.42	.73	.247	.044	.033
5411	52000	86000	15.0	20.5	167	.41	.81	.183	.053	.048
5412	46000	94000	19.5	24.0	179	.42	.82	.122	.057	.047
5413	49500	80000	12.0	16.9	149					
5413-2	29000	71000	21.5	49.1	131†	.37	.74	.106	.039	.035
5413-3	55000	91000	21.5	46.2	183*					
5414	39000	79500	25.5	40.3	156	.36	.74	.33	.045	.040
5414-2	41500	82500	20.5	27.4	175					
5415	42000	83000	25.0	40.3	156	.40	.81	.125	.042	.038
5415-2	42000	82000	25.0	40.3	156					
5416	45000	81000	19.5	24.0	159	.38	.95	.138	.048	.045
5417	49000	92000	16.5	20.5	187	.466	.86	.232	.031	.048
5419	49500	95500	14.0	16.9	187	.448	.83	.235	.034	.044
5420	52500	102000	18.0	20.5	192	.496	.75	.282	.022	.047
5421	46000	84500	25.0	34.0	156	.514	.84	.294	.039	.042
5423	57000	103500	17.5	24.0	207	.372	.80	.193	.058	.036
5424	44000	84500	22.5	34.0	167	.344	.75	.181	.046	.044
5425	52500	83000	12.0	16.9	163	.386	.78	.208	.044	.044
5427	54500	102000	16.5	20.5	197	.480	.85	.263	.055	.047
5428	55000	98500	12.5	16.9	197	.530	.84	.219	.045	.036
5430	55000	87500	16.0	20.5	171	.420	.83	.212	.046	.037
5431	52500	91500	19.5	24.0	171	.480	.79	.248	.059	.033
5432	46000	85000	22.5	31.2	163	.390	.82	.208	.048	.034
5433	51500	94000	19.5	30.7	175	.484	.67	.167	.044	.033
5436	52000	94000	17.5	24.0	171	.426	.78	.294	.054	.033
5437	48500	85000	24.5	30.7	163	.370	.80	.207	.052	.032
5438	54500	97000	19.5	27.4	187	.43	.78	.156	.035	.041
5440	41000	66000	22.0	27.4	131*	.20	.60	.113	.038	.042
5440-2	40000	67500	24.0	34.0	131*					
5441	50500	84500	14.0	16.9	163*	.34	.79	.199	.046	.038
5442	49000	96500	19.0	24.0	171	.546	.74	.261	.040	.038
5444	53500	94000	16.0	20.5	179	.440	.69	.240	.052	.037
5445	54500	93500	22.0	27.4	179	.492	.83	.234	.052	.039
5446	51000	85500	10.0	13.3	167	.534	.86	.235	.041	.047
5446-2	55500	88000	12.5	16.9	183					
5447	51500	75000	10.0	34.0	143*	.344	.70	.324	.048	.050
5448	54000	92000	13.0	16.9	179	.552	.77	.216	.052	.045
5449	55000	102000	18.5	24.0	192	.508	.80	.258	.049	.041
5450	47000	85000	16.0	16.9	163	.424	.79	.228	.040	.038
5451	44000	81500	18.5	24.0	163	.400	.69	.110	.051	.041
5452	52500	89500	14.0	16.9	163	.400	.85	.211	.053	.046
5453	46500	86000	17.5	24.0	163*	.36	.57	.188	.040	.038
5453-2	43000	85000	25.0	37.2	171*					
5454	49500	88500	12.0	16.9	171	.41	.67	.267	.046	.030
5455-2	48500	74000	12.5	16.9	153	.23	.80	.320	.037	.043

†Defective specimen.

*Special treatment.

Open Hearth Heats

Marks	Grade	Y.P.	T.S.	Elon.	Cont.	Br'll	C.	Mn.	Si.	S.	P.
C- 1	2 & 3	46000	83000	24.0	40.3	156	.40	.60	.216	.031	.041
C- 2	2 & 3	47000	87000	21.0	27.4	163	.39	.94	.317	.035	.034
C- 3	3	59500	109000	10.0	20.5	217	.53	.78	.195	.028	.032
C- 4	3	51000	88500	16.5	24.0	171	.38	.83	.267	.030	.040
C- 5-	2 & 3	43500	85000	19.5	27.4	156	.40	.42	.309	.031	.035
C-6	This heat was lost.		Trouble with stopper.				.41	.61	.318	.035	.031
C- 7	2 & 3	51000	93500	14.0	20.5	179	.43	.82	.301	.035	.041
C- 8	3	53500	93500	16.5	37.2	179	.40	.92	.165	.024	.041
C- 9	2 & 3	49500	83500	23.0	30.7	149	.36	.69	.251	.032	.031
C-10	3	51000	98500	17.5	16.9	179	.54	.76	.235	.033	.031
C-11	2 & 3	36500	76000	25.0	40.3	149	.30	.62	.181	.038	.038
C-11-2	3	33000	70000	22.0	27.4	137					
C-11-3	3	56500	92500	23.0	46.2	179*					
C-12	2 & 3	43000	81000	21.5	30.7	156	.37	.65	.143	.038	.038
C-13	3	49000	92000	16.0	24.0	179	.48	.83	.250	.034	.037
C-14	3	48000	75000	7.0	13.3	156	.38	.83	.227	.034	.040
C-14-2	2 & 3	47000	84000	15.0	16.9	163					
C-15	3	58000	101500	18.5	27.4	187	.40	.55	.241	.032	.030
C-16	1 & 3	49500	90500	14.5	20.5	175	.38	.63	.266	.042	.039
C-17	2 & 3	53500	93000	7.5	16.9	197	.47	.82	.216	.032	.043
C-17-2	2 & 3	46000	91000	14.5	30.7	171					
C-18	3	47000	93000	23.0	43.3	187	.43	.69	.110	.017	.031
C-19	2 & 3	51000	100500	17.0	24.0	187	.56	.74	.202	.018	.030
C-20	2 & 3	52000	103000	13.0	24.0	197	.53	.73	.153	.021	.039
C-21	3	45000	87000	15.0	24.0	171	.51	.68	.126	.024	.033
C-22	3	45000	97500	17.0	20.5	187	.56	.69	.258	.017	.044
C-23	3	46500	92000	17.0	24.0	179	.45	.23	.282	.045	.040
C-24	2 & 3	51500	103000	15.0	20.5	197	.51	.57	.155	.041	.032
C-25	2 & 3	50000	89500	18.5	24.0	171	.39	.64	.084	.037	.033
C-26	2 & 3	49500	88000	21.5	34.0	167	.38	.63	.208	.036	.033
C-27	2 & 3	57500	113000	14.5	20.5	217	.49	.71	.246	.048	.032
C-28	3	49500	91000	18.5	20.5	179	.44	.66	.142	.060	.038
C-29	3	55000	110000	14.5	20.5	217	.54	.65	.162	.042	.037
C-30	2 & 3	52500	83000	18.0	24.0	187	.43	.73	.213	.037	.043
C-31	2 & 3	50000	86500	18.5	20.5	167	.35	.78	.280	.052	.037
C-33	2 & 3	43000	89000	18.0	27.4	171	.44	.53	.140	.036	.035
C-34-4	2 & 3	49000	93000	19.5	24.0	179	.47	.49	.205	.050	.035
C-35	2 & 3	43500	79000	20.0	27.4	149	.41	.51	.245	.034	.043
C-36	3	48500	89000	12.5	20.5	175	.41	.59	.282	.045	.034
C-37	2 & 3	47000	89500	15.0	24.0	171	.44	.52	.262	.043	.034
C-38	2 & 3	43000	80000	17.5	20.5	149	.40	.51	.197	.032	.032
C-38-2	3	44500	80500	14.5	20.8	149					
C-38-2		43500	78500	13.5	20.5	165					
C-39	2 & 3	47500	94000	14.5	16.9	179	.42	.69	.242	.034	.033
C-40	2 & 3	53000	103500	16.5	20.5	197	.50	.79	.333	.043	.039
							.51				

*Special treatment.

Whatever degree of success is attained in the manufacture of small steel castings has been due to attention to details.

Investigations of difficulties have been made and, at the present time, every effort is being put forth to constantly

improve the product of the foundry. One of the tests which has been and is now useful in this respect is described below for the benefit of those who are not familiar with it.

Fig. 4 shows a side view of the Charpy impact machine and Fig. 5 an end view of the same instrument with the specimen in place for testing. This illustration also shows the form of a specimen used. In operation, the pendulum is elevated to a fixed height and then released. The specimen is struck a sharp blow and depending upon the amount of work absorbed by the specimen, the pendulum is retarded by a certain amount which is determined by the excess angle. The foot pounds absorbed by rupture can then easily be computed.

It is the practice to record this as foot pounds absorbed per square inch, using the data obtained from the small specimen in the same manner as computing the results from a standard tensile specimen. This is not rigidly true as the results obtained from different size notched specimens subjected to shock do not follow the simple laws of similarity which hold for tensile specimens. However, this method gives the significance of comparative figures which are understood by all concerned.

The following experiment serves to illustrate the effect of varying heat treatments upon the shock strength of plain cast steel of approximately 0.30 per cent carbon and 0.62 per cent manganese.

Annealed at 900 degrees Cent. for 2 hours, water quenched and drawn at 650 degrees Cent.

Foot pounds absorbed per square inch }
Average of 7 specimens.............. } 185

Annealed at 850 degrees Cent. for 2 hours, air chilled and drawn at 500 degrees Cent. for 2 hours.

Foot pounds absorbed per square inch }
Average of 8 specimens.............. } 153

Annealed at 900 degrees Cent. for 2 hours, furnace cooled.

Foot pounds absorbed per square inch }
Average of 8 specimens.............. } 146

It will be noted from these results that the water-quenched and drawn casting is superior to any other treatments as far as shock is concerned. The air-chilled casting is also superior to the furnace cooled.

Many experiments such as the above are being conducted and as previously stated in this paper, it is thought that ultimately high-grade alloy castings will replace many parts now being made of forgings. Although the very term casting brings up unpleasant thoughts in the minds of many designers, it cannot be disputed that by the very nature of the method of manufacture, a casting has one decided advantage over a forging.

This advantage lies in the fact that the physical properties of a casting are the same in all planes if the annealing and casting operations have been properly carried out.

It is a matter of common knowledge that the physical properties of a forging are widely different in different planes. In some exaggerated cases, the elongation may be 22 per cent in one plane whereas it is practically zero in a plane at right angles. As long as suddenly applied stresses are confined to the plane having good ductility, failure will not ensue, but if by any chance, suddenly applied stresses occur in the planes having poor ductility, failure is almost certain.

The static tensile test comes far from telling all of the truth especially when the specimens are taken in one direction only. The Charpy impact test will pick out these cases of absence of ductility in certain planes and it is for this reason that its use has been successful.

Whenever abrupt section changes occur in any place, stresses will be set up under shock action, which are not usually considered by the designer. As forgings are apt to have different physical properties in different planes, disaster may result. If such parts are made of high-grade castings, which are carefully tested and inspected unforeseen failures are apt to be less frequent, by virtue of their uniform quality in all directions.

In view of results obtained on the Charpy impact machine, investigation at the Watertown arsenal leads to considerable optimism in the eventual replacement of many high-grade forgings with castings. Furthermore, this replacement will result in considerable saving of time and money, when such castings can be produced commercially.

Discussion—Steel Castings for Ordnance Construction

Mr. Wilson:—I would like to ask a question about the cooling in the standard heat treatment. We are manufacturers of steel and I would like to have the benefit of your experience in heating and slow cooling. What method would be best and most efficient in the manufacture of this grade of steel?

Major C. M. Wesson:—By what process are you making the steel?

Mr. Wilson:—The electric furnace.

Major C. M. Wesson:—I have had no experience in the manufacture of steel by the electric furnace. I am very glad to say, however, that we are about to put in a considerable electric furnace installation at the Watertown Arsenal. From the very excellent reports I hear of electric steel I should first endeavor to obtain the required physical qualities in the castings by an annealing treatment, which should produce the desired result. The reason on which this belief is based is that you should have a minimum of slag and oxides for it is principally the slag difficulty in steel that militates against ductility. In the converter there is much slag which is inherent to the process the effect of which can be lessened only by good refinement. Now if you have less slag to contend with, you can meet the physical qualities very much more easily, that is by a less severe treatment. This is proved by our experience with the acid open hearth, for when we use clean stock, get the steel hot, sometimes holding it in the furnace 10 to 15 minutes after the gas is shut off before tapping, and likewise holding it from 5 to 10 minutes in the ladle before casting, we reduce the slag and oxides by such an amount that we are enabled, without difficulty, to get the No. 3 grade physical qualities by simple annealing. Of course in the acid open hearth, if you are hurrying your heats, you are apt to have them cold and very much

oxidized. Then if you hurry them into the ladle and kill them with a lot of aluminum they are so cold that you have to hurry them into the mold. We find that this sort of practice gives bad results. With the electric furnace there ought to be no aluminum difficulties.

MR. FRANK HODSON:—I should like to congratulate Major Wesson on his excellent paper which brings out so vividly the necessity for active co-operation between the manufacturer of steel castings and the scientist. The old days when a casting was judged solely by the skin appearance and when output was more important than quality have gone. Modern manufacturers are realizing that proper control by skilled metallurgists of chemical, physical and heat treatment means ultimate success and Major Wesson's paper is proof of the advantages to be gained by following such methods.

Although the paper deals chiefly with the manufacture of carbon steel castings made in the converter and open-hearth furnace and their subsequent heat treatment, I feel it would be worth while for this meeting to consider the supreme importance of making a good sound steel in the first place. No amount of heat treatment will change a badly made casting into a good one, and I was very pleased to hear the question asked Major Wesson as to the part that the electric furnace could play in making good castings and enabling manufacturers to fulfill government specifications.

It will probably interest the members to know that the electric furnace has been very widely adopted in England for the manufacture of small, intricate ordnance castings and the results obtained far surpass anything obtained by either crucible, open hearth or converter. In the manufacture of some of the newer engines of war and of aeroplanes, great difficulty was found in getting ordinary steel and castings to stand the terrible strains demanded. The electric furnace has solved the problem—although I cannot agree with Major Wesson that an acid-lined electric furnace is more suitable for the work than a basic-lined furnace. My own experience is just the reverse and the circulation of the bath—bringing the metal in contact with refining slag and also freeing it from occluded oxides and gases is very much more important than the relative

acidity of the lining. In most types of basic-lined electric furnaces the slag can be controlled more easily than in an acid-lined furnace.

I was pleased to see Major Wesson give special attention to holding the metal from converter or open hearth for 10 minutes before casting. This undoubtedly frees the metal from many slag occlusions. Some types of electric furnaces obtain the same result by the slow circulation of the molten metal in the furnace during melting, and this may account for the fact that such castings require very little annealing and that they can be bent double cold as cast.

MAJOR C. M. WESSON:—I did not quite get your remarks in regard to acid or basic.

MR. FRANK HODSON:—I referred to your statement in the paper.

MAJOR C. M. WESSON:—I based that statement simply on information I have. It appears that the slag difficulties are less in steel castings made on acid bottom in the electric furnace than those made on basic. However, it is of course possible to make entirely satisfactory steel on a basic bottom.

MR. FRANK HODSON:—We found that with the ordinary electric furnace, a basic hearth made exceptionally good castings. This work was done at an arsenal in England, one of the largest in the world. They are making steel on the basic bottom with an electric furnace and they deem it very good. I don't think the acid would really hold.

MAJOR C. M. WESSON:—In that connection we have had recently some very interesting experimental guns made from basic electric furnace steel. Of course this is an extremely important matter at this time, particularly in the foundry industry. Our capacity is well known and it is no secret that our capacity is very inadequate and a great many people are going into the manufacture of gun steel. We have had reports from two places that are refining in basic electric furnaces and the results have been exceedingly promising. Until recently we have had little information about gun forgings made from electric steel, in fact, at all the big steel plants the universal practice for gun forgings has been acid open hearth. Apparently they have not gone into the electric process due to the

fact that the majority of ingots required for guns are much too large for the size of electric furnaces in use up to within recent years. But now as a large number of small guns are going to be made by new concerns, the electric furnace apparently offers a splendid opportunity to do successful work.

MR. A. M. HENDERSON:—I would like to ask Major Wesson a question. We have been operating for some years with 2-ton converters on specifications which are not quite as severe as your No. 3. In heat-treating, our experience was that as soon as we got out of 900 degrees we reduced the elastic limit and also reduced our tensile strength.

MAJOR C. M. WESSON:—With regard to the higher temperature for the No. 3 steel, you will note that there is a very slight difference over that used in No. 2. It was found that 900 degrees for the No. 2 was sufficiently high to produce satisfactory results, but that where great refinement is essential with the higher carbon, somewhat better structures are obtained by slightly exceeding this temperature.

MR. R. A. BULL:—Mr. Chairman, I feel that Major Wesson has performed a very great service in presenting this paper. He has gone into the details of foundry practice at the Watertown arsenal in a way that is most instructive to the foundrymen of this country. Some months ago, the committee on papers asked me if I would prepare some statement, to be presented at this convention, on behalf of the association, indicating its attitude toward helpfulness to the government during the war. Knowing that Major Wesson was to present a paper, I wrote him advising him of the committee's request upon me, and I asked the major if he thought any discussion of his paper might suitably bring out the remarks that the committee had in mind for me to make. I did not then know the title or nature of Major Wesson's paper.

In his reply, the major explained that he would treat the subject of steel castings for ordnance use from the standpoint of ordnance experts, and he made a statement in concluding his letter, which I cannot quote exactly, but the nature of which I remember very well. He said, substantially, that he thought the viewpoint of a commercial manufacturer of steel castings would be very different from that held by ordnance officers.

I am sure the major did not intend any personal allusions to myself, nor do I know whether he intended that anyone should make the interpretation of his statement that I am making, but when Major Wesson said that the point of view held by commercial steel casting manufacturers was quite different from that held by ordnance experts, he made a statement which was very true and was very significant. There have been material differences of opinion as to specifications and other details in the past. A more significant thing is that, at the present time, we are on a very different basis. If there is any information that the ordnance officers can give the foundrymen, such officers are more than willing to give it, and likewise the foundrymen are more than willing to extend any co-operation to the ordnance experts. As foundrymen, we want the government to be able to get steel castings, or any other castings, in ample quantities and of suitable quality to meet the government's requirements. I am sure that I speak for all the foundrymen of the country, irrespective of their membership in this organization, when I say we earnestly wish to co-operate to the fullest extent with the ordnance officers of the army and navy in supplying castings that will properly serve the purposes for which they are intended.

Cast-Iron Shells in Permanent Molds

By Major Edgar A. Custer, Philadelphia.

The present conflict has brought about wonderful changes in the generally accepted ideas of warfare. The terrible curtain of fire has made its appearance, earthworks and trenches have been substituted for elaborate and costly fortifications and the aeroplane and submarine have profoundly influenced the strategy on land and sea. In the trenches, old-time stink pots and grenades are being thrown by the ancient catapult, bombs are shot from a contrivance that closely resembles a home-made Fourth-of-July cannon and the form of slingshot that David used on Goliath, has been modernized to a wonderfully effective point. Now we have the spectacle of an unheard of number of rapid-fire, high-caliber guns raining upon the enemy, myriads of cast-iron shells. The continued use of these apparently grotesque contrivances and the revival of cast-iron shells rests on the fact that they have been found to be the most effective means for doing the work in hand.

Cast-Iron Shells Not New

There is nothing new in the use of cast-iron projectiles—before the age of steel they were the sole means of battering down defenses and attacking at long range. Some of the reasons why the use of cast-iron shells was abandoned are that the metal has never had a very good reputation for uniformity and freedom from sponginess and gas holes; its tensile strength is low and it lacks toughness. Any of the defects commonly found in cast iron will seriously affect the trajectory and direction of a shell and render it comparatively useless. It must be absolutely reliable and land at the point at which it was aimed. If one portion is spongy and hence lighter, it will wobble in flight and its main purpose will be destroyed. The weakening effect of sponginess or blowholes may cause the shell to break under the shock of the initial explosion and

destroy the gun. A forged steel projectile meets all these objections and has the call.

The objection to steel projectiles is that they are comparatively ineffective against earthworks or trenches when the caliber is 5 inches or less. The amount of contained explosive is small and a great proportion of the explosive effect is used in bursting the walls of the shell. In larger sizes this objection is less apparent. The explosive effect increases with the added charge in a greater ratio than the strength of the added amount of metal in the projectile. The present war has taught us that steel, concrete and brickwork offer but little resistance to modern seige guns and they have been abandoned for earthworks manned with an ample force. The burden of attacking must and does rest with the artillery and the army that is equipped with the most effective guns using the most effective projectiles, will win the most battles. The projectile that is most efficient against earthworks and covers its zone of dispersion with the greatest number of fragments of the proper size is the projectile that will surely be used. It only remains to make that projectile so that it not only will be strong enough to resist the propelling explosion, but also will be perfectly sound and uniform in texture.

Target Shells Do the Work

During the Spanish-American war, when our fleet was off Santiago, it was observed that one vessel was creating great havoc in the earthworks guarding the entrance, and upon investigation, it was found that this vessel was using loaded practice shells. These shells would tear great holes in the works, while the steel shells were comparatively ineffective. As the vessel had quite a number of these shells in stock, it became very popular with the other ships. A few years ago, some experiments were made on the lower Chesapeake to determine the effect of cast-iron shells on the superstructure of a condemned war vessel. One shell that penetrated the structure and burst in a wardroom was particularly observed. The room was about 20 x 60 feet and one side was lined with lockers. Every locker was torn to pieces and the paint on the walls and ceiling in the line of the explosive force was cut off as with a sand blast. It was the unanimous opinion that the explosion would have

killed every man who happened to be in the room at that time. A few tentative experiments were made after this and a permanent mold was constructed, but the project was allowed to drop and no effort was made to thoroughly investigate the subject.

The first intimation we had that cast-iron shells were being used in the present war, was an article in the *London Engineer,* which described a number of fragments of cast iron that were undoubtedly portions of an exploded shell. It was noted that some of the pieces were slightly chilled on one side and the *Engineer* surmised that cast-iron cores were being used. As the peculiarly destructive effect of these shells was observed not only in the open, but also against earthworks, the idea that the Germans were using cast-iron shells on account of the scarcity of steel was abandoned. As a matter of fact, as early as May, 1913, German and Italian munition makers were discussing this phase of projectile work and were seeking all the information that was available. In August, 1913, it was reported to the writer that shells had been made that were satisfactory in that they had the proper degree of fragmentation and were strong enough to resist the effect of the propelling charge. Moreover, these shells were made in iron molds with iron cores.

Theory of the Cast-Iron Shell

The theory of the cast-iron shell is that, when used against earthworks, the greater part of the explosive force is not expended in bursting the walls of the shell and the effect is as if that amount of explosive were detonated in the earthwork. When used in the open, the great fragmentation of cast iron will allow the shell to burst into a far greater number of pieces than a steel shell and will cover the zone of dispersion very closely. It is essential for the work that the degrees of fragmentation be calculated to a nicety. Too great fragmentation will make the shell ineffective. A steel shell weighing 13½ pounds, when charged with one pound of TNT, will burst into approximately 1050 pieces if there is complete detonation. The largest pieces average 0.3 to 0.4 pound in weight and many of these are splinters due to the fibrous nature of the metal. The fragments recoverable have a wide variation in weight, as shown

by the fact that while the average weight of the large fragments is almost half a pound, the average weight of all the fragments is about 0.01 pound. It follows that a very large per cent of the fragments would do no harm or at least would not disable except at very close quarters. A cast-iron shell under the same conditions would burst into nearly 1500 pieces with the fragments comparatively uniform in size and weight. It has been found that wide differences in the fragmentation of steel shells have been caused sometimes by the incomplete detonation due to the primer failing to function properly. This is not so serious with the weaker cast iron, but serves to emphasize the fact that a large proportion of the explosive force is expended in bursting the steel walls.

Target shells have been made of cast iron for many years and almost any foundry can make them. It is only essential that the casting be solid and capable of being machined to the proper sizes. The weight of the bursting charge is made up by thickening the walls. If it is not up to weight, a little sand is poured into the cavity. When it comes to making a projectile of cast iron that is to be used against an enemy, a number of difficulties are set up. It must be very strong, it must be easily machined, it must be absolutely solid and free from spongy spots and blowholes, and above all, every shell must have exactly the same degree of toughness. To meet these requirements, the foundry must be run on a strictly scientific basis. There can be no guess work or slipshod methods. When shells are cast in sand, the elements of carbon, silicon and manganese must be held to very definite limits, and these limits vary with the thickness of the shell walls. Moreover, these limits can only be determined by trial. The point aimed at is the correct degree of fragmentation and all foundry methods must be carried out with this point in view. Dry-sand molds, open and porous; perfect cores and trap or swirling gates must be used. The foundry requirements for this work have been ably set forth in an article by Edgar A. Custer Jr., in the April, 1917, issue of *The Foundry* and the methods of melting and care of iron and fuel described must be carried out whether the shells are made in sand or in a permanent mold.

Ordinary foundry iron when properly cast in a permanent mold and when removed at the proper time, has, in the resultant casting, the same degree of hardness irrespective of any variation in the chemical constituents, so long as the same size, weight and shape of casting is made. The time the casting remains in the mold is the determining factor of the degree of hardness. A casting weighing about 60 pounds remains in the mold four or five seconds, while a casting of the same general contour weighing 500 pounds will require from 25 to 60

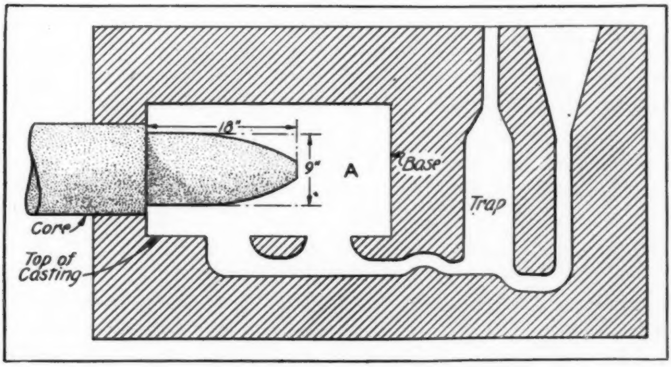


FIG. 1—TWO-PART CAST-IRON MOLD OF SHELL BUSHING WITH 15 INCHES OF METAL SURROUNDING GATES, RUNNERS AND CASTING

seconds before it is safe to lift it out. To illustrate this point, data on a casting weighing 1100 pounds is presented. Fig. 1 shows the general outline of a mold that was used to make a shell bushing. It will be seen that a trap gate was used and that the casting had a very heavy base and comparatively thin upper walls. In fact, about 65 per cent of the total weight was concentrated in the lower third of the casting. This large mass of metal increased the time interval in that it was necessary to set the walls deeper than in a casting of smaller bulk. There were no risers and the only means provided for the escape of air from the matrix were a few shallow channels cut into the mold at the top of the casting. A large cast iron core operated by a hydraulic cylinder formed the interior

cavity. The mold was opened and closed by a similar cylinder. Into this mold irons of the following analyses, all of which were melted in an ordinary cupola, were poured:

	Mixture No. 1	Mixture No. 2	Mixture No. 3	Mixture No. 4
	Per Cent			
Manganese	1.50	0.50	0.80	1.50
Sulphur	0.03	0.05	0.06	0.03
Silicon	1.05	1.75	2.25	1.05
Phosphorus	0.05	0.06	0.06	0.05
Steel Scrap	....	....	....	16.00

From 10 to 12 castings were poured from each of these irons and when the castings were broken, not one showed the least sign of sponginess or gas holes. The mold was poured full and the first part to freeze was the entrance gate so that there was no possibility of feeding. Only enough iron was poured to fill the cavity.

The time of setting was measured by the time the core remained in the casting before it was safe to draw it. No. 1 iron required 1 minute and 20 seconds before the core was drawn. When the core was allowed to remain in the casting 1 minute and 30 seconds, it was gripped by the iron and had to be cooled to room temperature before removal was possible. No. 2 iron required 1 minute, and No. 3, 30 seconds. In No. 4 a new condition was set up when 16 per cent of scrap steel was melted with the charge in the cupola. In this case it was 2 minutes and 20 seconds before the core could be withdrawn. The results show that in a casting of this size, the low silicon iron cools much slower than one of higher silicon content. The effect of the long time in the mold was to make the casting very hard and heat treatment was given to bring it to machinability. The temperature of the core had no effect on the time of setting, the tenth casting was given the same time as the first, although the core was heated to a temperature of over 400 degrees Fahr.

Mold for a Sixty-Pound Shell

A mold was made for a shell that, when finished, weighed 60 pounds. The mold was made in three parts, as shown in Fig. 2, and was equipped with a cast-iron core. It will be seen

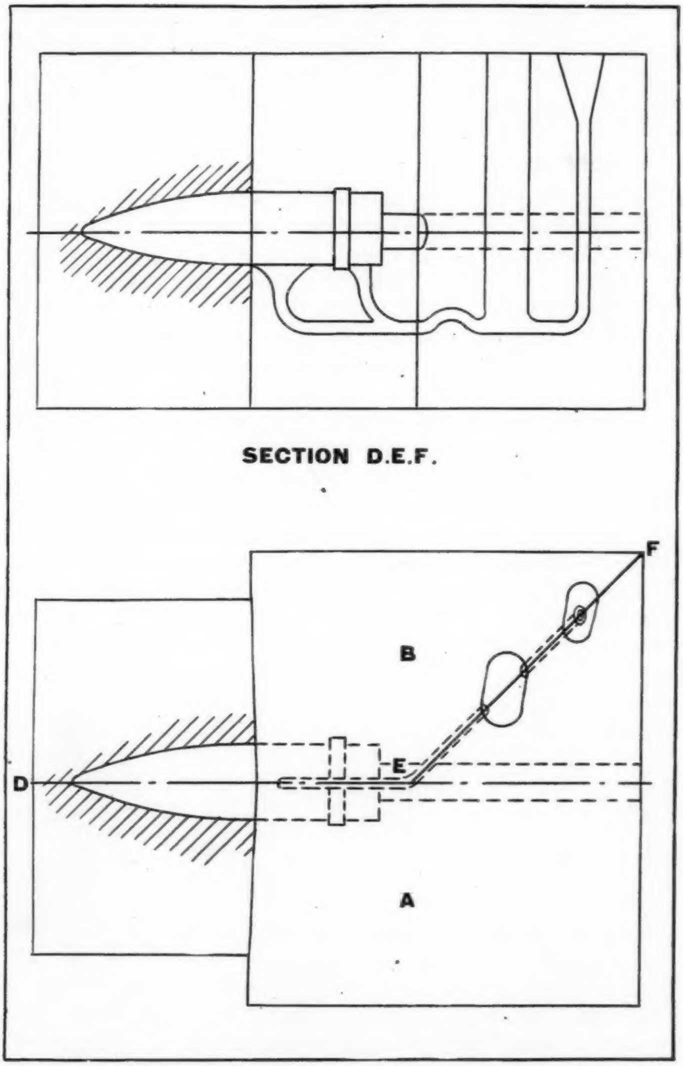


FIG. 2—SKETCH OF THREE-PART PERMANENT MOLD FOR A 60-POUND SHELL

that the portion of the shell forward of the bourrelet is cast in the solid part of the mold and no provision is made for venting. The parting of the movable portions of the mold runs in a straight line through the center of the shell and extends 3 inches beyond the base. It then turns at an angle of 45 degrees and runs straight the remaining distance to the outside of the mold. The pouring cup is placed about 5 inches from the outer end of the parting and the main sprue runs down to an easy curve to the bottom of the trap. The entrance to the trap is ¾-inch in diameter, while the main sprue is 1½ inches in diameter. The trap gate is 5 x 4 inches with heavy filleted corners and open at the top. The sides are given ⅛-inch draft, so that the moving parts of the mold will open readily. The bottom of the trap is set low enough to allow a slight hump to be placed in the runner between the trap and the matrix. This hump serves to catch any air or dirt that may be carried with the first rush of the metal. The center line of the runner is 3 inches below the bottom of the matrix and two gates are cut—one between the revolving band and the base and the other between the band and the bourrelet. The gates are 1/16-inch wide and have a small fillet where they enter the matrix. The mechanism for drawing the core is attached to the part *A* and moves with it. Channels are cut in *A* and *B* in the proper position to receive the copper band. The operation of casting is as follows: The copper band is placed in the channels, the mold closed and then poured as fast as the runner will take the metal, keeping the pouring cup full until the end. In four seconds the core is withdrawn, the mold opened and the casting removed. The copper band will be firmly cast into place.

It was found that a mixture corresponding to No. 4 in the experiment previously mentioned, with the exception that the manganese was under 0.08 per cent, gave the casting the toughness necessary for the proper degree of fragmentation, but the long exposure in the mold made the casting too hard. A scleroscope reading of 65 to 70 was the invariable result irrespective of any difference in the mixtures. It was evident that some form of heat treatment was necessary to bring the casting to a workable condition. It had been determined that a mark

of 45 would give the proper degree of fragmentation. Quite a number of trials were made before it was found that a "flash" heat of 865 degrees Cent. would restore the casting to a good workable condition and bring the scleroscope to just about the correct figure. It was further found that the castings should be allowed to cool before being subjected to the treatment so that a number of shells could be treated at the same time, starting at the same basis of temperature. If the heating furnace has sufficient heat capacity, it requires about 20 minutes to bring the castings to the right temperature and they are then allowed to cool free from drafts.

In a permanent mold, it is impossible to get a casting free from gas or air holes without the use of trap gates. There is no trouble in filling the mold when semisteel is used. The metal does not need to be poured especially fast. Nevertheless, unless a substantial trap gate is provided, small holes will collect against the bottom of the core and the top of the casting. The most careful pouring will not change this condition. There is a point when semi-steel can be poured in a permanent mold without these holes forming and without trap gates, and that point is when the metal has cooled until it is almost viscid. The difficulty of successfully hitting this point is so great as to make this method beyond the range of commercial success.

Time a Vital Factor

The difficulties that lie in the way of making a cast-iron projectile in sand have been set forth. Some of these troubles may be avoided by the use of a permanent mold. The selection of different irons for different sizes of shells is not necessary. To explain this, one must take into account the fact that the influence of silicon and manganese is exerted only when the molten metal is cooling in the mold and the total effect of this influence is measured by the time the molten metal takes to become solid.

In a sand cast projectile weighing 65 pounds, the time is five minutes, in a permanent mold casting the time is five seconds. The softening effect of silicon is due to its property of forming graphitic carbon—in itself silicon is a hardener. A casting with no carbon and high in silicon would be hard as glass. It requires a certain amount of time to form the

graphite flakes and if this time is reduced to a minimum, the formation of these flakes will be prevented. Graphitic carbon will be present, but it will be in such a finely divided state as to be practically amorphous. It resembles the temper carbon of a malleable casting, but is uniformly distributed throughout the structure. Now if the time of setting is so short as to prevent the formation of graphitic flakes, it must follow that under these conditions, silicon has no softening effect. The same statement may be said as to the effect of manganese. A moderate amount of manganese will add strength to a sand casting and is a valuable constituent for a great variety of work. In a permanent mold casting the effect is to make the casting hard and brittle.

When cast-iron shells are used in the open, the fragmentation must be exact, but when used against earthworks, only the explosive force counts. Since it is impossible to set aside shells for each duty, it is obvious that the degree of fragmentation must govern the process. This is easier to accomplish with a permanent mold than by any other known process. As has been said, the question of hardness does not depend upon the variations of the pig iron so long as ordinary foundry iron is used. The same statement is true of the so-called semisteel so long as the same percentage of steel scrap is melted with the iron. The term "ordinary foundry iron" is used to denote pig iron ranging from 1.75 to 2.75 per cent silicon, below 0.80 per cent manganese and with sulphur below 0.08 per cent. Phosphorus has no appreciable effect up to 1.00 per cent. A casting that would analyze 3.00 per cent total carbon, 1.00 to 1.20 per cent silicon, 0.06 per cent manganese, 0.05 per cent sulphur and 16 per cent steel scrap would be an ideal composition for a 60-pound shell. All shells whether cast-iron or steel, must be subjected to a definite heat treatment and, in the case of cast-iron, the degree of heat and time of exposure to get the proper scleroscope test, can be determined only by experiment.

The Design of the Mold

Now a word about the design of the mold. The main point to be considered is that plenty of metal should surround not only the matrix, but also the sprues and runners. In a casting

such as a 5-inch shell, there should be at least 10 inches of metal outside of every portion of the mold that comes in contact with the molten metal. The purpose of this is twofold, to provide a sufficient heat storage capacity so that the molten metal will be robbed of its heat in the shortest possible time and to make the mold strong enough to resist the tremendous expansive power of the cooling metal. The matrix and the core should be made to the exact size of the casting before finishing. Make no allowance for shrinkage. Why there is no apparent shrinkage when these castings are made in a permanent mold is a moot subject. It may be that since the interior of the casting is molten when it is taken from the mold and the outside contraction has not started at the time of removal, that the expansive force of the cooling interior metal will neutralize the contracting force of the cooling exterior. It is a very interesting point, but it is true that when the casting is so thick that the interior is molten at the time of removal, shrinkage may be safely ignored.

As a further item of design, the mold should be so equipped as to be easily and quickly opened and closed. The movable portions should run on grooved wheels fitting V-shaped tracks. The purpose of this is to prevent small particles of iron interfering with the adjustment of the moving parts. Casting is apt to be a sloppy proceeding and there are always small particles of iron splashing around. Mount the molds so that there is plenty of space underneath to collect any molten metal that may carelessly escape. Before closing the mold, run a flat scraper over the face to remove any small particles that may adhere. If these general rules are followed out, two 60-pound shells can be cast every minute and all will be of the same weight, size and texture.

There is one very important point in the manufacture of cast-iron shells that must be considered and that is the position of the copper revolving band. In some steel shells this band is placed within a very short distance of the base, but in a cast-iron shell, plenty of metal must back up the band. Even with the strength that steel gives, portions of the base are sometimes torn off by the tremendous force set up when the band enters the rifling at a very high velocity. The effect of this rupture is to

disturb the trajectory and direction to such an extent as to render the shell not only useless, but dangerous. When the guns are behind the line, pieces of the band, base and even the projectiles may fall into friendly ranks with disastrous results. In a 5-inch shell, the distance between the band and the base must be at least 2½ inches and the band must be sunk into the body of the shell only sufficiently deep to hold it in position. If this point is not observed, the cast-iron shell will be a failure.

When the large projectiles are cast, there is a tendency to form wrinkles on the exterior and interior of the casting due to the surge of the metal while pouring. This is an annoying feature, but the remedy is to make the main runner, where it enters the trap, the controlling factor. If the diameter at that point be kept so small that the main runner can be kept full of molten metal during the entire pouring, these wrinkles will not be in evidence.

Steel Castings in Permanent Molds

The question arises as to the use of steel in permanent molds for the purpose of making shells. The added strength of this metal and the ease with which it can be brought to specifications in the open hearth, is certainly attractive. There is no doubt as to the suitability of steel for this work and it will readily pour in a permanent mold. Moreover, it is not hardened or weakened by the action of the mold. The grain is very fine and it yields exceptionally well to heat treatment. The main difficulty is that the process of casting in a permanent mold is a continuous performance, while the melting of steel in an open hearth is more or less intermittent. The steel when it comes from the open hearth must be poured without delay and after the metal in the ladle is poured, there must elapse an interval of hours before the next heat is ready. Furthermore, the economical melting of steel demands that it be made in furnaces of large tonnage and to pour this tonnage within the time limit within which the steel remains sufficiently molten to work, would require an immense number of molds and an elaborate and costly equipment to handle the ladles, operate the molds and take care of the castings. If the melting of steel can be economically accomplished, so that a continuous supply

of molten metal is available, then the manifest advantage of steel over cast iron can be utilized.

When steel is cast in a permanent mold, an allowance must be made for shrinkage, as there is not the same initial expansion as is the case with cast iron. A greater bulk of mold must be provided to take care of the higher temperature and the gates, trap and runners must be given a coating of heavy clay wash after each pouring. This is necessary to prevent cutting the mold. A very slight under cut will put the mold out of business until repairs can be made. Once the "sting" of the molten metal is taken away by the runners, gates and trap, steel will do no harm to the matrix.

French Specifications

The French government has issued specifications for shells cast in sand that are here given in part. They call for the analysis of shells of 122 to 155 millimeters caliber. The chemical analysis is as follows:

	Per Cent
Graphitic Carbon	0.70
Combined Carbon	2.40
Silicon	1.35
Manganese	0.70

The amount of total carbon and silicon must not exceed 4.7 per cent. If this limit is exceeded, the iron will lack toughness. At least 2 per cent of the total carbon must be combined to produce proper fragmentation. The percentage of dust increases as the combined carbon decreases.

Although the sum of total carbon plus silicon is set at 4.7 per cent, it is preferable to keep these limits to 4.4 per cent with a minimum percentage of silicon. The percentage of silicon varies according to the type of molding. In the 122-caliber the best results were obtained by using a minimum of 1.20 per cent silicon for dry sand and 1.35 per cent for green sand. The percentage of silicon varies in inverse ratio to the thickness of the walls and the caliber, the thicker the wall, and higher the caliber, the lower the silicon. Manganese decreases with the thickness of the walls and caliber and increases with the sulphur.

The sulphur should never exceed 0.08 per cent and should be lower whenever possible. The percentage of phosphorus is set at 0.15 per cent or under. The charge should be as follows:

	Per Cent
Pig Iron	40
Scrap	40
Steel	20

The term scrap is used to denote scrap melted, pigged and charged according to analysis.

These specifications correspond closely to the iron previously mentioned as being ideal for use in permanent molds. The striking point in the specifications is that the silicon decreases when a dry-sand mold is used, and this point is emphasized by the use of a still lower silicon in a permanent mold. The percentage of combined carbon will always be high when a permanent mold is used. Once the proper mixture has been determined, that mixture is used irrespective of the thickness of walls or caliber of shell.

All the foundries of France engaged in this work, have been mobilized on a common basis and are using precisely the same methods of selection, analysis and general foundry procedure. This has not been done without enormous losses and vexatious delays, there have been many cases where the loss of the total heat has been reported and a loss of 40 per cent was not uncommon in the first stages. Team work, scientific methods and keeping everlastingly at it, have brought results. Today the output has reached staggering proportions—over 1,000,000 rounds per day are being made.

Disadvantages of Forgings

Starting from the pig, the manufacture of a steel forging involves many operations and a huge outlay for equipment. The steel is made, poured into ingots, rolled into rounds, cut into blanks, heated to the forging temperature, pressed into the rough shape, pierced and run through a draw bench before the forging is ready for machining. A shell cast in a permanent mold and starting from the pig has but two operations—melting and molding. The heat treatment of the steel shell before

machining is completed is balanced by the heat treatment of the cast-iron shell before machining.

A steel forging for a 4.7-inch shell costs over $7.00 at the present writing, while a casting for the same shell can be made for a little over $2.00. Furthermore, a liberal saving in labor and machine-tool consumption can be effected. When larger projectiles are made, a larger proportionate saving will follow. When more than 1,000,000 rounds per day are made, and this is a low figure to expect, the difference in cost seems incredible. If $6,000,000 or $7,000,000 are spent each working day for shells alone, the incentive for saving a substantial portion of this tremendous outlay becomes a vital necessity especially when the cheaper shells will give as good if not better service than the more costly ones. There is no comparison between the shells when the question of output is considered. Taking dollar for dollar invested in equipment, the output of cast-iron shells is 10 times greater than the output of steel forgings.

The low cost, great output per day and the effectiveness of cast-iron shells have been so completely recognized that two of the warring nations are using them to an enormous extent. France is casting them in sand and Germany, from the best information available, is casting them in permanent molds.

Are Our Foundrymen Awake?

It is very hard to come before a body of intelligent and experienced men—men whose achievements have set the pace for the world—and say, that at this writing, it is doubtful if there is a foundry in the United States that could qualify at once for this work without material changes in procedure. Primarily, it is not a commercial proposition and if this government decides to use cast-iron shells, the work must be undertaken with the foreknowledge that trouble is ahead. The necessity will be paramount of not only putting forth prodigious efforts but also of sinking individuality for the common good. A full and free interchange of ideas and data is indispensable. There is no doubt of the ultimate outcome, but if the experience of those who have been through the mill is utilized, a deal of time, trouble and treasure will be saved.

Discussion—Cast-Iron Shells in Permanent Molds

Mr. A. O. Backert:—Mr. Chairman, I think this paper is too important to permit it to go by without adequate discussion. We are informed by the ordnance department that the time has not yet arrived for the use of cast iron for shell purposes in this country. We think this is mighty unfortunate. At the League Island Navy Yard in Philadelphia they were making permanent molds by the Custer process and today semisteel shells are being made, but of course the shells are used only for practice purposes. This shell question is all important, and it does seem to me that if the cast-iron shell can be used successfully by our enemies, it likewise can be used successfully by us. I would like to ask Major Custer if he can tell us why hand grenades are more satisfactory and have greater destructive power when made of malleable iron instead of semisteel, cast iron or steel?

Major E. A. Custer:—It is due to the peculiar toughness of malleable iron. That is the only thing I can say. Ordinary foundry iron will invariably powder when a high explosive is used. The walls of the hand grenades are comparatively uniform in thickness, and the nearer you get your walls to uniformity, the better fragmentation you will get, given the same explosive effect in each case. In the case of malleable-iron hand grenades there is no initial shock, and all you have to provide in that case is the ability to fragment properly. You have no occasion to look further than that. If it were not for the initial shock it would not be difficult to make a cast-iron shell that would be perfect in fragmentation. You must have toughness and rigidity in the casting in order to successfully meet the requirements. That is the only explanation I have.

THE CHAIRMAN, MR. A. W. WALKER:—Mr. Fuller, can you add anything to this question?

MR. B. D. FULLER:—I don't know that I can, except to say I have been interested in experiments which have been conducted along the lines spoken of by the secretary and Mr. Custer—experiments dealing with the difference between the efficiency of the cast-iron and malleable-iron hand grenades. We found that when the cast-iron hand grenade is exploded there remains scarcely anything of it except powder. I don't know how effective the semisteel was although I think it was not much more satisfactory. Malleable iron seems to be the effective material in that there is larger fragmentation. For instance, a cast-iron grenade exploded inside a pine box about an inch thick did not do the desired damage, not nearly the damage that the malleable-iron grenade did. The fragments of the malleable-iron grenade went through the inch board like a bullet, whereas the pieces of the cast-iron grenade did not. The government, while I cannot speak authoritatively, seems to be of the opinion today that malleable iron is to be used in the manufacture of grenades to an almost exclusive extent.

The Manufacture of Cast Ammunition in France

BY E. RONCERAY, Paris, France

The war which has been engaging the attention of the civilized world for over three years has made necessary the introduction of new processes in the foundry as well as in other industries. When my American friend, Mr. John A. Penton, came to France and visited me last year, it was not then apparent that America would join us in the fight for freedom. However, Mr. Penton was impressed by some of the things he saw in this country and these probably were the basis for the kind invitation extended by your association to exhibit some of our French machines equipped for ammunition work at your convention. Unfortunately, however, the scarcity of men here is so great that I could not possibly accept this invitation.

The need for ammunition is great and exceeds what was conceived to be necessary, even by the most visionary. It is a well-known fact that five weeks after the declaration of war, the battle of the Marne ended when the French and Germans had practically exhausted their entire supply of shells. It was a tragic and critical moment and every means was resorted to to obtain shells, even though imperfect. It was at this time that practice shells, made of cast iron and containing only a small amount of explosive, were used and these were produced as quickly as the foundries could turn them out. The 75-millimeter (2.96-inch) steel shell gave such excellent results that every effort was made to secure them and even small shops were asked to bore and thread steel bars to produce these shells in two parts, one for the body and one for the cap. This imperfect type of shell and that made of cast iron saved the day for the 75-millimeter rapid fire gun which was the most important weapon in use at that time. Steps were taken immediately for the manufacture of forged shells on an extensive scale and the output at present is so great that we are furnishing large quantities of them to our allies.

A different problem was presented in providing shells for the large guns. With the increase in the diameter of the shells, manufacturing difficulties increased more rapidly. More time was required to make the large shells and to organize for their production in large quantities. It was then that the feasibility of using cast shells was seriously considered.

It is well known among ordnance experts that the destructive effect of a projectile increases in proportion to its size more rapidly than the weight of the explosive it contains. Therefore, steel had the preference for shells in spite of the great cost of the raw material and the high cost of machining. Cast iron shells used as substitutes for steel were of a small capacity on account of the great thickness of wall it was necessary to provide, to insure adequate resistance to the ballistic action of the powder.

Semisteel Shells

The *fonte acierce,* that is cast material and what is known as semisteel, was considered and was selected finally for producing a comparatively cheap, quickly manufactured and reasonably effective shell. The Germans can vouch for this. Since the beginning of 1915, an enormous number of these projectiles from 80 to 400 millimeters (3.15 to 15.71 inches) have been made and fired for the cause of civilization. In addition to the semisteel shells an enormous amount of grenades and projectiles of all kinds have been made of cast iron in France.

The metal required for semisteel shells was defined by the following data, based on the tests made in this country by the ordnance authorities and railroad companies. The test piece is a square bar, 40 x 40 x 200 millimeters (1.57 x 1.57 x 7.85 inches) long, cast on end in green sand with a riser. It is tested on two knives spaced 160 millimeters (6.30 inches) apart, by a falling weight of 12 kilograms (26.41 pounds). The initial drop is from a height of 28 centimeters (11 inches) and the weight is raised 1 centimeter (0.254-inch) after each blow until rupture occurs. The average breaking height must not be less than 45 centimeters (17.71 inches).

The tensile test piece is 18 millimeters (0.71-inch) in diameter x 150 millimeters (5.91 inches) long, cast on end and

turned down to 16 millimeters (0.63-inch). The breaking strain must not be less than 25 kilograms per square millimeter (39,900 pounds per square inch).

Hydraulic tests of 10 seconds duration, before banding, are made at a pressure of 300 kilograms per square centimeter (4500 pounds per square inch) for the shells up to 160 millimeters (6.30 inches) and 200 kilograms (3000 pounds per square inch) for the larger sizes. Other tests after banding are made with compressed air or steam at 5 kilograms per square millimeter (75 pounds per square inch).

Allowance for Casting Imperfections

A reasonable allowance is made for small defects difficult to eliminate entirely in practice, particularly when a great production is required. Small defects are passed externally in front of the band provided their thickness can be determined exactly with a needle and extend into the metal less than one-fourth of the wall thickness.

No defects are permitted at the back of the band except small, interior depressions due to imperfect coring, provided that the thickness is not more than 2 to 3 millimeters (0.079 to 0.118-inch) and that the bottom of the shell is sound.

No definite analysis is enforced provided the physical tests are satisfactory. In fact, the metal is a low phosphorus, low sulphur and low carbon iron with a sufficiently high amount of silicon and a sufficiently low amount of manganese to leave it soft under the conditions of pouring.

Typical analyses of semisteel shells follow:

	Diameter of Shell, 120 millimeters (4.74 inches) Per cent	Diameter of Shell 155 millimeters (6.11 inches) Per cent
Total carbon	3.25	3.06
Silicon	1.34	1.17
Manganese	0.66	0.61
Phosphorus	0.08	0.08
Sulphur	0.10	0.17

To obtain a very strong metal it may be melted either in an open-hearth or electric furnace. which insures a low

carbon product with some degree of certainty, or by mixing cupola and converter metal. Thermic treatment will considerably improve the physical qualities. Tensile strengths of 35 to 40 kilograms per square millimeter (50,000 to 57,000 pounds per square inch) have been obtained regularly by these processes. This metal, however, increases the casting difficulties as it has a tendency to develop blowholes owing to its lack of fluidity. However, for the heavy tonnages required in a short time, the cupola, well handled, gives satisfactory results and regularly produces metal that passes the necessary physical tests. The bulk of the semisteel shells made in France, either for the allies, or for ourselves, have been cast of cupola metal and therefore I will limit my discussion to this process.

The Cupola and Its Equipment

The standard cupola, as built in America, is capable of producing good semisteel. The tuyeres, usually one or two rows close to each other in large cupolas, must be of the standard type, that is, flat and one-sixth to one-fourth of the section of the cupola. It is advantageous to employ a cupola, equipped either with a hearth for holding a certain amount of metal, or provided with a receiver. The use of a receiving ladle is not recommended, as very hot metal with regularity of composition is essential. If a cupola equipped with a receiver is employed, provision must be made to heat the receiver white hot before pouring, or the first metal will be dull.

A blower of ample size is required and it is more advisable to have one of too large a capacity than one that must be driven to the limit to provide sufficient blast. I prefer a positive pressure blower to a fan, as the former insures better control of the melting.

Lining for the Cupola

The best lining is none too good as all operating conditions are against its long life. The extended heats necessitated by the large outputs required, the exceedingly hot temperature needed for good metal, the large amount of coke

burnt at each melt combined with its low quality at the present time and the large amount of limestone generally used, result in the rapid wear of the lining. Owing to the high cost and scarcity of refractory material in France, many foundrymen have adopted sand linings and it must be admitted that in a great many instances these linings have given equal, if not better results than refractory brick. A good refractory sand is selected for this purpose and it should be rammed hard between the shell of the cupola and a wood form. It is then carefully dried and blacked. In wearing qualities it compares favorably with the best refractory brick. A thick lining, 12 inches or more, is recommended.

The proportion of steel used in the mixture depends on the composition of the initial iron. If low carbon irons are employed, the amount of steel added must be less than if high carbon pig is used in the mixture. As a rule, the hematite irons now supplied contain more carbon than required, cold blast iron with low carbon content not being produced here in large quantities. Therefore, it is necessary to add a large amount of steel to the charges in order to reduce carbon in the final product. It is admitted that in the cupola process, steel before melting, absorbs 1.6 to 2 per cent of carbon. Taking this into account, it is easy to calculate how much steel must be added to reduce the carbon percentage to the correct point. In French practice, up to 40 and even 50 per cent of steel is used. The amount generally charged, however, is from 15 to 30 per cent, according to the quality of the initial iron.

Composition of Final Product

The final product varies for different sizes of shells and according to the methods of molding pursued. The shell casting must be softer for the smaller projectile, or more exactly, for the thinner shell, and also it must be softer when the metal is poured in green sand molds than in dry sand. The physical properties of the test bars do not measure the final quality of the product. Therefore, test bars from the projectiles themselves are necessary. Such tests, together with actual firing practice have shown that

the best results are obtained when at least 20 per cent of the total carbon is in the combined form, this percentage being as high as consistent with the possibility of machining the shells. The total carbon is kept at about 3 per cent. Less than 2.75 per cent gives a sluggish metal which is difficult to handle and liable to produce unsound castings. Above 3.25 per cent carbon results in the production of castings that are too weak.

Several methods are pursued for controlling the combined carbon. One is to alter the amount of silicon; another is to change the amount of manganese which seems to act in opposition to the silicon, and a third is to change the speed of cooling. Silicon precipitates carbon in the graphitic form and, consequently, reduces combined carbon; manganese has a reverse action, while combined carbon increases with the speed of cooling.

Since the amount of manganese in the iron and steel we are using is about right, it has not been the practice to vary their percentages according to the silicon content. The speed of cooling is not easy to control and the only consideration given this factor is in connection with the change that takes place when the thickness of the shell is varied or the adoption of dry, or green sand molding methods. Silicon is the element most easily controlled and it is due to its control that semisteel shell manufacture has been successful in this country.

To arrive at the minimum amount of silicon acceptable, a test is made under the usual working conditions of the plant and the shells that are slightly hardened at the point, are analyzed. These will contain the lowest admissible silicon percentage.

Experience has shown that to obtain a sufficiently strong metal, the empirical rule

$$\text{T. C.} + \text{Si} = 4.50$$

must be satisfied. This is the maximum amount of silicon.

For instance, if total carbon = 2.80 per cent then Si = 4.50 — 2.80 = 1.70 per cent.

If total carbon = 3.10 per cent then Si = 4.50 — 3.10 = 1.40 per cent.

The amount of silicon must be kept between the limits of 1.40 and 1.70 per cent, the one corresponding to the minimum of silicon giving the maximum resistance permitted without having chilled castings or shells that are too hard and the other corresponding to the maximum of silicon, above which the castings would be too weak. Care must be exercised to have these figures refer to the final product and, therefore, provision must be made for silicon losses in the cupola.

In working between these limits, analyses made of the actual castings will show that the percentage of combined carbon will be more than 20 per cent of the total carbon necessary to give a satisfactory shell metal. If this figure is not attained, the physical test will not be satisfactory and the shells, when tested will be shattered into small splinters, similar to dust, whereas when 20 per cent or more of combined carbon is obtained, the splinters will be larger and will be more like those of forged steel shells.

Regarding the other elements, phosphorus and sulphur must be kept as low as possible, but it may be stated that satisfactory shells can be made with as much as 0.15 per cent phosphorus and 0.12 to 0.15 per cent sulphur. Phosphorus reduces the strength, but increases the fluidity. Sulphur is without much effect on the strength, but it reduces the fluidity and retains carbon in the combined form. Its action is counterbalanced by the manganese. Sulphur, however, has a tendency to produce blowholes when the metal is not poured at high temperatures and when the mold is not gated to prevent the entrance of air into the mold with the iron.

Chemical Composition and Physical Test

Maximum resistance to shock must not be sought, as the tensile strength will not be satisfactory. It must be remembered that a sample giving a high shock resistance will fail in the tensile test, and *vice versa.* A test bar, breaking under a high falling weight, undoubtedly reveals sluggish iron liable to produce blowholes and to chill at thin points. The tensile test probably will not be satisfactory. Under

these circumstances, reasonable limits must be fixed in both directions and the rules outlined will enable this result to be obtained.

If a high figure for the falling test and a low tensile test are obtained, silicon must be added.

If the tensile test is high and the falling test too low, carbon must be reduced.

Steel and ferrosilicon, or high silicon iron, are the two agents that will best serve the metallurgist, care being exercised to take into account possible variations in the initial metals used.

Analysis and Rapid Tests

It is helpful, of course, to analyze the initial and final products. Though it is difficult to rely entirely upon the regularity of the materials received, it must be admitted that analyses, properly made, are important. All materials should be analyzed, especially iron, scrap, coke, limestone, sand, core oil and finished castings. After a short time these analyses will provide a certain amount of fixed data which will enable the metallurgist to handle with a greater degree of certainty the factors that are liable to change from day to day. For instance, phosphorus, sulphur and manganese will remain about the same for each brand of iron, sulphur for each brand of coke, and limestone and sand do not vary much if received from one source. Silicon loss and carbon gain in the cupola will not change much if the same practice is followed every day.

Other factors, on the other hand, are liable to constant changes; these include silicon in pig metal, moisture in the sand, composition of the core oil, etc. Therefore, analyses must be made as frequently as seems necessary under the circumstances, always keeping in mind that *it is a practical impossibility to work only from analyses,* particularly *on account of the irregularity of the materials.* In fact, it may happen that the samples analyzed do not represent the average analyses of a car lot, or that a few pigs in the car are entirely different from the balance; also, steel scrap varies in composition, etc. It also must be remembered that

if a mistake is made, the analysis of the final product will point out the corrective measures that must be adopted.

Either Keep's or a chill test should be made constantly to determine roughly if the amount of silicon is right. If not the iron may be pigged and a part of the loss recovered, or the iron can be improved by additions in the ladle, or changes in the subsequent cupola charges. It is the prevailing practice to add powdered ferrosilicon in the ladle when the iron is too hard.

It also may be necessary, when the product is too variable, to pig a certain amount of metal, for instance, to prepare a low carbon metal from hematite iron and a large percentage of steel to use instead of scrap. If this metal is analyzed it makes more certain obtaining a satisfactory final product. Some firms knowingly increase their amount of foundry scrap of known composition by making the risers much larger than is really necessary.

These processes increase the regularity of the work, but at a heavy expense in time and money and they only must be resorted to when all other means have failed.

A useful, rapid test consists of taking a sample of metal every half hour and pouring it against a chill. The sample is plunged into water when set and is broken immediately. An experienced eye can tell quickly the depth of chill that gives the right metal for the needs of the foundry. This depth is not the same for all classes of shells; it must be less for small, or thin projectiles, than for heavy ones. I prefer this to another test recommended by the ordnance department, which consists of pouring cones into open sand molds from time to time, and after cooling, the points are broken off for the purpose of ascertaining from the fracture if the metal is right.

Operation of the Cupola

The operation of the cupola is similar to that for ordinary work. However, the amount of coke used is somewhat more than the usual average, but not so much as might be imagined. It is generally from 12 to 15 per cent of the charges and this is essential on account of the necessity

of having metal much hotter than is obtained usually, if sound castings are to be made. It must be borne in mind that a blowhole which would be unimportant in a machinery casting would not be passed in a shell. Also, it must be remembered that a certain amount of carbon is absorbed by the steel charged before it melts. Some foundries are using up to 20 per cent coke, but the writer considers this bad practice, as satisfactory results are obtained with a smaller amount. However, in spite of the high price of coke, foundries must not be tempted to reduce its consumption to less than that necessary to obtain the best results. Good shells only are obtained regularly when the temperature of the iron at the cupola spout is about 1450 degrees Cent. and it must never be less than 1250 degrees Cent. when entering the mold. Unfortunately, there are few practical methods of readily measuring the temperature of a stream of iron.

In charging the cupola, the rules laid down by Richard Moldenke may be followed. However, it has been found that better results have been obtained by increasing both coke and iron charges by 50 to 100 per cent over what he recommends. That means that coke charges are 6 to 8 inches high and iron charges in proportion. Different methods are followed for charging limestone and variations in the amounts used also prevail. With the poor grade of coke now furnished in this country, containing from 16 to 18 percent of ash, some foundries use up to 12 per cent limestone and add it to all charges, including the bed. This means that charging 12 per cent coke, as much limestone as coke is used. Other foundries use two and one-half times as much limestone as ash in the coke. Good results are obtained with 5 to 6 per cent of lime. Good limestone contains about 50 per cent lime.

The pig iron should be broken into small pieces, but it is still more important to use steel in small, rather than large pieces, as the action of cementation which takes place before liquefaction takes some time and would not be completed if the pieces are too large.

Report of A. F. A. Representative on Joint Committee for Classification of Technical Literature

You will perhaps recall a brief report at last year's convention, made by your representative, who had been appointed to represent the American Foundrymen's association on the joint committee for the classification of technical literature. This joint committee consists of representatives of every important technical and industrial association in the country, and has been at work devising the best method of cataloging and indexing technical books and articles for city, private and works' libraries.

At the request of this committee, your representative undertook to work out a list of titles covering the iron foundry industry, the expectation being that the steel and the non-ferrous foundry industries would work out their own lists later on. During the year the classification of titles was made, and also duly sent to the joint committee in question and never acknowledged or further heard of. In order, however, that the work may not be lost, and that it may be subjected to criticism and extension by the A. F. A. membership, and be available when the joint committee gets busy again, it is given herewith. The undersigned will be glad to receive corrections and suggestions, and offers his services freely for the consummation of the very desirable and necessary project of indexing foundry literature in catalogs of public and other libraries with sufficient care and minuteness so that a foundryman desiring to look up something may do so with success and reasonable speed.

What is given in this report may be ten times more than is necessary, but it will serve to show the diversity of the general subject and the paucity of titles in existing library catalogs dealing with the foundry.

Dr. Richard Moldenke.

Suggested Classification of Foundry Literature

The Foundry

A.—Generalia
B.—The Layout of the Shop
C.—Equipment
D.—Raw Materials Used
E.—Molding Processes
F.—Melting Processes
G.—Pouring Methods
H.—Finishing Processes
I.—Laboratory and Testing Methods
J.—The Castings

A.—Generalia

a.—History of Foundry
b.—Place in Manufacturing Industry
c.—Relation to Finance
d.—Relation to Raw Materials
e.—Relation to Labor
f.—Relation to Customers
g.—Association Work
h.—Organization and Management
i.—Operating Policies
j.—Specialization of Work
k.—Costs
l.—Generalia

B.—The Layout of the Shop

a.—Grouping of Departments
b.—Building Design and Materials
c.—Yard Conveniences, Receiving and Shipping Facilities
d.—Heating, Ventilating and Sanitary Provisions
e.—Safety Provisions and Fire Risk
f.—Plan of Operation, Routing of Materials and Storage
g.—Provision for Expansion
h.—Generalia

C.—Equipment

a.—Cranes: Hand, jib, overhead trolley, electric traveler, gantry. Operated by hand, steam, hydraulic, electric, compressed air power
b.—Molding Machines: Squeezers, power machines, jolt machines
c.—Ladles: Hand, crane, bull, trolley, shank
d.—Tumbling Barrels: With or without exhaust; sand-blast barrels
e.—Skull-cracker
f.—Cupola: Shell, lining, tuyeres, blast-pipe, tap-hole, spout, etc.
g.—Blower Equipment: Positive blower, centrifugal blower, fan
h.—Air furnace
i.—Open Hearth Furnace: Gas producer, oil-burning system, powdered coal, natural gas equipment
j.—Crucible Furnace: Coke-fired, gas or oil-fired regenerative
k.—Converter
l.—Electric Furnace
m.—Power Equipment: For operating pattern shop, carpenter shop, lighting and ventilating plant, air compressor, elevators, sand-mixing machinery, tumbling barrels, grinding wheels, pumps, etc.
n.—Elevator and Sand Conveying Apparatus
o.—Sand-Blast Equipment
p.—Pattern and Carpenter Shops
q.—Annealing, Heating Ovens and Soaking Pits
r.—Sand Grinding and Mixing Apparatus
s.—Industrial Railway Systems
t.—Core-Room Equipment
u.—Generalia

D.—Raw Materials

a.—Metals:

1.—Pig iron: Basic, Bessemer, foundry, malleable Bessemer, spiegel, forge, low phosphorus, Scotch, silvery, white, washed, etc.
Anthracite, coke, charcoal, electric, oil, etc.
Cold, warm, hot-blast

2.—Foundry Scrap: Foundry made: Sprues, gates, discounts, "oven iron"
Bought Scrap: Gray Iron: Machinery, stove-plate, car wheels, brakeshoes, cast borings, grate bars
Malleable: Light and heavy
Steel: Light and heavy; steel borings
Mixed material: Briquettes, cabbages

3.—Ferro-Alloys: Ferro-aluminum, -magnesium, -manganese, -molybdenum, -nickel, -silicon, -sodium, -tungsten, -titanium, -vanadium, -chromium

4.—Deoxidizers: Ferro-titanium, -aluminum, -manganese, -silicon, -magnesium, -vanadium, silico-spiegel, spiegel
5.—Generalia: Sampling, analysis, specifications, testing, piling, grading (obsolescent), etc.

b.—Fuels:
1.—Wood, charcoal
2.—Coke: Bee-hive, by-product, breeze
3.—Coal: Anthracite, bituminous, gas, cannel, pulverized coal, slack
4.—Lignite
5.—Oil: Paraffine and asphaltum base
6.—Gas: Natural, producer and oil.

c.—Fluxes:
Oyster-shells, calcite, dolomite, limestone, fluorspar, "fakes"

d.—Refractories:
1.—Fire sand, core sand, mica schist, ganister, silica brick
2.—Molding sand, loam
3.—Fire clay, fire brick, bauxite, magnesite, chrome brick
4.—Generalia: Analysis, manufacture, acid, basic and neutral refractories, degree of refractoriness, etc.

e.—Facings: Sea-coal, blackings, mineral facings, graphite, soapstone, etc., (facing sand)
f.—Parting Materials
g.—Core Binders
h.—Generalia: Ore, packing material for malleable, etc.

E.—Molding Processes

a.—The Pattern: Wooden and metal, solid and split, skeleton
b.—Molding: Green-sand, dry-sand, loam, open sand molds, lost wax process
Bench molding, floor molding, pit molding
Plate molding, bedded-in molds, chill molds, die molds, permanent and long-life molds
c.—Gating: Top, bottom, whirl, horn, spoon gates, runners, risers, pouring basins
d.—Hand molding, machine molding, jolting, ramming by hand and power, returning pattern, rapping, skin-drying, core-setting
e.—Flask, cope and drag, cheek, venting, chaplets, bottom-board, shell, weight, completed "mold"
f.—Core-making: Core sand, binders, boxes, iron, print, plate, wire, barrel, green-sand and dry-sand cores, "blowing"
g.—Generalia

F.—Melting Processes

a.—Combustion: Analyses of fuels, calorific values, flame temperatures, waste heat, technology of combustion

b.—Processes: Crucible, shaft furnace (cupola), reverberatory furnace (air furnace), open hearth furnace, bessemer converter, electric furnace

c.—Operation: Cupola repairing, charging, melting, tapping, dropping bottom, efficiency, melting rate, melting ratio, melting loss

Air furnace, making bottom, charging, melting down, rabbling, skimming, tapping, repairing

Open-hearth furnace, hand and mechanical charging, melting, tapping, repairing, producer gas operations

Electric furnace, melting, refining, pouring

d.—Generalia

G.—Pouring Methods

a.—Direct metal teeming

b.—Ladle pouring, top and bottom pour

c.—Centrifugal casting, vacuum casting

d.—Pouring troubles, internal chill, internal strains, dirty castings, cold-shuts, shot, etc.

e.—Generalia

H.—Finishing Processes

a.—Cleaning Processes: Shaking out, sand blast, pickling, tumbling, hand brushing

b.—Finishing Processes: Grinding, chipping, repairing (burning-on, welding and brazing)

c.—Coating Processes: Galvanizing, sherardizing, tinning, dipping (asphalt)

d.—Generalia

I.—Laboratory and Testing Methods

a.—Chemical Analysis: Methods of sampling and analysis of pig and cast iron, fuels, molding sand, refractories, etc.

b.—Physical Tests: Test bars, tensile, transverse; impact, hardness, inspection of castings, shop tests for shrinkage, fluidity, chill, etc.

c.—Micrographic Analysis: Microscope, photography, heat treatment, etching, other preparation of samples

d.—Specifications: For pig iron, coke, refractories, molding sand, supplies

e.—Generalia: Research work, etc.

J.—The Castings

The General Divisions would be Cast Iron, Malleable Cast Iron, Steel and Non-Ferrous Castings

For the Cast Iron and Malleable, the following would rule:

a.—Classification by Process of Manufacture:

1.—Direct metal
2.—Crucible process
3.—Cupola
4.—Air furnace
5.—Open hearth
6.—Electric furnace

b.—Classification by Type:

1.—Gray iron castings (machinery castings, etc.)
2.—Chilled castings (carwheels, rolls, etc.)
3.—White iron castings (grinding plates, hard castings for malleable process, etc.)
4.—Malleable castings

c.—Classification by Variety:

1.—Acid-resisting
2.—Alkali-resisting
3.—Agricultural
4.—Annealing pots and boxes
5.—Bed plates
6.—Brake shoes
7.—Car wheels
8.—Cylinders (air, ammonia, automobile, hydraulic, gas, locomotive, steam)
9.—Crusher plates
10.—Grinding shoes and balls
11.—Electrical
12.—Engine frames
13.—Fire pots
14.—Grate bars
15.—Flywheels
16.—Gears
17.—Glass molds
18.—Gun iron (air furnace metal)
19.—Hardware and novelty work
20.—Heat-resisting
21.—Ingot molds (all pig iron)
22.—Machinery castings (light, medium and heavy)
23.—Malleable castings
24.—Ornamental work
25.—Pipe and fittings (water and soil)
26.—Piston rings
27.—Plow points
28.—Pulleys
29.—Radiators
30.—Rolls (chilled and sand)
31.—Sash weights
32.—Stove plate
33.—Valves

34.—White iron castings

d.—Chemistry of Cast Iron:

1.—Iron with carbon, silicon, manganese, sulphur, phosphorus, oxygen, aluminum, chromium, copper, magnesium, nickel, titanium, vanadium, etc.

2.—Mixture-making, use of steel scrap, etc.

3.—Generalia

e.—Physics of Cast Iron:

1.—Fusibility, melting point, freezing point

2.—Fluidity, "life", cold-shuts, shot

3.—Thermo-physics of cast iron

4.—Grain structure

5.—Porosity

6.—Specific gravity, ferrostatic head

7.—Chill

8.—Hardness, softness, machinability

9.—Shrinkage, feeding, pumping

10.—Expansion and contraction, cooling curves

11.—Segregation

12.—Strength, tensile, transverse, elastic limit, deflection, torsional, shearing, resilience

13.—Electrical properties, conductivity, hysteresis, magnetic permeability

14.—Corrosion, electrolysis, rusting

15.—Endurance

16.—Resistance to friction, heat, cold, chemical action, wear

17.—Warping, cracking, stretching, etc.

18.—Generalia

f.—Metallography of cast iron

g.—Generalia

Apprenticeship Training

By W. B. Hunter, Fitchburg, Mass.

In an epoch-making book entitled "Eclipse or Empire", Doctor Herbert B. Gray of Oxford, England, has roused the complacent Englishman to a realization of the fact that England is no longer the industrial and mercantile leader of the world and shows them that this decadence is due primarily to neglect of recognizing the necessity of a democratic educational system founded on a scientific industrial basis. It is a severe shock to him and a warning to us that unless we are to face this same condition in our turn we have got to look sharply to our educational system.

Dr. Gray says: "Man was born to be a creator. Insofar as he fulfills that mission he earns the crown of manhood; insofar as he shirks it, he becomes a drone in the human hive, a tramp, a useless burden on the earth. Business is the efficient conduct of those manifold operations which are involved in the creation and supply of the ever-growing needs and necessities of mankind. Business is essentially creative; it aims at linking up the powers of nature and of man, at the minimum of waste in methods and materials employed. It creates plenty where once there was want; it makes a granary out of a wilderness; it bids a thirsty land riot with water; it stabs the frosty soil with spade and plow; it uncovers the bosom of nature until she becomes pregnant with life and brings forth fruit a hundred fold."

Business, and by business I include all forms of endeavor, is a profession just as much as law, medicine, or the socalled arts and as such, demands a preparation just as vigorous if not even more so. The habit of school authorities of looking upon business as a sordid, subordinary occupation for those of mediocre mentality is slowly and in some quarters, very slowly, being dissipated. The insistent demand of the world's progress, for more, more and more speed and accomplishment

has at last reached the archaic cloisters of our pedagogs and they are stirring. An uneasiness, a feeling that all is not right with our educational system is rousing them from the rut of classical hero-worship. Yet we cannot blame the teacher very much; he has been giving the public what it has long demanded, a polish of mental activity. The business man and employer have been growling that the product of the schools is no good and has let it go at that. Business is his vocation, teaching the teacher's and this *laissez faire* policy has resulted in our present-day condition where industry is crying out, yes shrieking, for skilled laborers and it cries in vain. Where a generation ago young men considered it a privilege that they gladly paid to learn a trade, today we have to offer all sorts of inducements to encourage their enlisting in our workshops.

What is the Cause?

What is the cause of this condition and what is the remedy? First we must recognize the changed character of our population and the conditions of living, both social and economic. In the pioneer days every man was expected to work and he did work; he had a religious background that believed in the proverb that "by the sweat of a man's brow must he earn his bread". There were no objectors, "conscientious" or otherwise, to that doctrine, and the son and daughter subscribed to the same doctrine, not "let father or mother do it". An indentured system of long hours and six or seven years' service insured a thorough grounding in the principles and practice of the trades. It was the accepted rule that the boys enter a trade or business house at an early age and the law did not recognize as today that the longer you wait to start the better off you'll be. A look at the stern and sturdy visages of our pioneers will convince you they meant business. But prosperity and an influx of workers from Europe, with a gradual lowering of these moral standards, caused a change. American boys began to aspire to the softer or clean collar jobs. It was no longer *en regle* to work; let the "dago" do that, and this sentiment has consciously or otherwise been fostered by our schools. The bright boy has been counseled to go to college and study for the professions, the dullard is told to get out and go to work,

what's the use of training his head, workers don't need brains. Parents, too, today seem to think that education spells "work eliminated". Thus these agencies coupled with the craze for amusement and the use of socialistic ideas that the emigrants have brought in, has tended to draw away from physical effort many who must by circumstances or nature, work for their livelihood at some form of productive labor.

Another element has been the enormous increase in the use of automatic machinery. Employers have said "we don't need all-round mechanics, we want operators", and to make apprenticeship less desirable, higher wages are an immediate inducement to the operator, while the apprentice must wait four years before he can realize a respectable pay envelope.

What is the remedy? Education, both of employer and employe. Where shall it begin? In the only right place, the public school. We are taxed to support the school. What does the school turn out? Workers, some will say shirkers, of all sorts, office workers as well as shop workers. You take one of these into your plant. Has he been trained for your job? If not, why not? Is it right to support a system of education that trains all for doctors, or lawyers, whose curriculum ignores the boy who wants to work as a mechanic, the 95 per cent student? We prate about our democratic school system, but it is not, it is rather the opposite. The proscribed German aims to train every man for some particular job and some one for every and all jobs. Even the unskilled have a course of training. Compare this with our slipshod, go-as-you-please, do-as-you-please system.

Industrial Education

In the last few years we have heard a great deal about industrial education in this country and the house has passed the Smith-Hughes bill to fasten industrial and agricultural education on the various states, provided certain requirements of administration are met. Some $50,000,000 are to be spent in an effort to stimulate this form of education. Now to my mind there is just one way to make this program effective and useful. The state should require that every citizen be prepared for some useful occupation. Proper supervision should

be available to assist parents and compel them also to determine that for which their child is best fitted. We should see that the children receive such training as will enable them to attain the highest rank their natural ability and endowments can command.

There may be objection that this is a stupendous task, but I submit that the proper education of every individual is a social, economic and moral qualification that the state should demand in return for the priceless privilege of American citizenship. It is because of this neglect that we have the "I won't work nor let others work either" problem on our hands today. True we have been busy building up our country's resources but isn't it time for a good big look into our human resource pile. Universal military service will be a help, only let it begin early.

In our efforts to train boys in quantities for the trades, the pedagogical idea of a trade school was first developed, but the result has been that about 95 per cent have, on graduation, gone not into a trade, but into almost every other line of work. The reason for this result is evident enough; lacking practical work and teachers, a book system was adopted and exercises leading nowhere but to the scrap heap could not be expected to enthuse a real boy in a trade; rather it drove him out of it. From this first condition there has gradually developed schools with teachers of real trade experience making articles that are useful and practical but there are limitations to most all of them. First, only those boys who can afford to go to college can go to a trade school and spend four years' time and receive no pay. Second, the real commercial shop atmosphere is lacking. Some say, make things to sell that are commercial. Immediately you compete with the shop organized completely for business. Now everybody knows that the city in 95 cases out of a hundred pays vastly more for any project than a private business enterprise, and so how are you going to sell at a profit? But why try to compete? Why not put the boy into the shop already in existence and instead of taking boys away from industry put them into it at the age they should go into it. Let them go to school to get the theory of their trade and to the shop to practice it.

That is what the co-operative system of trade training does. The apprentice is indentured as the old-time boy was, but instead of working in the shop, week after week, he spends alternate weeks in shop and school. The city gives him a real, live commercial education that fits his vocation. His teachers are real tradesmen, who know the whys and wherefores and by discussion and study of shop methods and operations, mathematics, chemistry, etc., which the mechanic usually spends a lifetime in getting under the old system, the young mechanic gets somewhere in some time.

Instead of having to go to night school or take up a correspondence school course after a hard day's work, he goes to the school provided by the citizens and employers whose taxes paid for it. Isn't that logical? The big taxpayers are the manufacturers and employers; the students must go to work in their plants. Then let them be taught a bread and butter curriculum and let's get over this so-called cultural idea that we have so long worshipped.

Shop and School United

That is the basis of the co-operative idea; shop and school united to the decided advantage of the boy and of course to the employer also, for no system can be successful that ignores either. Instead of loafing through a high school course and at the end wondering where he can land to continue his game of bluff, he leaves to work and it's no hardship at the end of his school term to continue working. He has his job already cinched and finding one is not his to worry about.

Ten years' trial of this system in Fitchburg, Mass., has demonstrated its efficiency. Parents, the boys and their employers are all pleased with the results. The city may well say that it is a dividend-paying proposition for the pay these boys receive while at work is from four to five times the cost of instruction. The wages are 10 cents an hour for the first period of 825 hours, 11 cents an hour for the second period, 12 cents an hour for the third period, 13 cents an hour for the fourth period, 14 cents an hour for the fifth period and 15 cents an hour for the sixth period.

That is, beginning with the second year in high school, the boy while working receives a raise after every period of 825 hours. His shop term is 30 weeks long and school term 20 weeks long per year. The shop rules and regulations apply in every particular, while the apprentice is at work the same as the school rules apply while in school.

Thus you can see that the school holds the boy who would otherwise be lost because there was nothing in the classical course to suit his mechanical tastes and the trades are made attractive by being raised to a level with the classical courses. The contact of these workers with the other students has not resulted in the least sign of social ostracism for these boys are the leaders in athletics and they have the "coin" for the social affairs which makes them desirable companions for the fair sex.

Our graduates are the future foremen and skilled mechanics of our city. They already are occupying positions as assistant chief draftsmen, designers, superintendents, heads of departments, foremen, inspectors, to say nothing of well-paid mechanics, molders, draftsmen, etc. They are doing their bit for Uncle Sam, too, no less than a dozen serving in the army and navy as machinists' mates, radio operators, electricians, etc. We have organized our regular apprentices, those who do not go to school, on the same pay basis, but with a longer period of service.

Our foundries have had difficulty in getting apprentices for some time and it became apparent that something radical must be done to remedy this condition. Here is what the Putnam Machine Co. did and the result. This company advertised a one year's course for special apprentices, over 21, in different branches of foundry practice, giving a rate of 30 cents an hour for first six months and 35 cents an hour for next six months. Applicants were carefully scrutinized by the superintendent and required to sign a bond with responsible surety for faithful service. As a result, 23 were accepted for the one-year term. So many applicants continued to apply that a two-years' bond was executed and signed by many and it is even possible to secure them for a three-year term. Money talks. It is very evident by this that we have got to offer

more money than has been the case in the past, and why not? When a hodcarrier, plumber, carpenter and others whom I could mention get from $5 to $6 a day and upward with much shorter hours than the machine shop has ever offered, is it any wonder we find boys who are looking for the dollar a bit shy of the shop. One remedy may be more money for our product.

We have had special apprentices in our machine shops for some time, offering instructions in the operation of one machine to older men who wanted to get into the machinery trades, but who could not afford to serve three years at regular apprentice pay and it has been very satisfying as to results. Every avenue whereby help may become more skilled and intelligent should be taken advantage of by the employer. There is the continuation plan so successful in Minnesota, which gives specific training in schools for four or five hours a week to those already engaged in trades. This is not lost time from work as many imagine for the mental quickening which the workers receive more than compensates.

Now there is not the slightest doubt but that legislature is going to compel you to educate your workers by some method. Why not be up and awake to the problem? Study it and be ready to present a logical, practical and efficient plan to your school authorities rather than have a pedagogical, theoretical, expensive makeshift thrust upon you because of your inertia. The great trouble with our business men is that they are so busy looking on the inside of their own business that they forget that they are under obligation to render some service to their community. The more you are alive to the community's problem and its solution, the greater will be the benefit to you and your own business problems.

Appendix

Rules and Conditions Under Which Special Apprentices Taking the Four-Year Co-operative Industrial Course at the High School of Fitchburg are Received for Instruction

1.—The applicant for apprenticeship under this agreement must have satisfactorily completed the first year's work prescribed for this course at the High School.

2.—The apprentice is to work continuously, well and faithfully, under such rules and regulations as may prevail at the works of the above company for the term of approximately 4950 hours, commencing with the acceptance of this agreement, and in view of the reduction of the number of hours from the regular apprenticeship course, the apprentice is to complete the prescribed course at the High School to the satisfaction of the High School authorities.

3.—The employer agrees to give the apprentice the opportunity to familiarize himself with the .... trade or business and to learn its fundamentals.

4.—The apprentice shall report to his employer and to the High School for work on alternate weeks when the High School is in session and to his employer on all working days when the High School is not in session, except during vacation periods provided below, and he shall be paid only for the actual time he is at work for his employer.

5.—The apprentice is to have a vacation, without pay, of two weeks each year, during school vacation.

6.—The employer reserves the right to suspend regular work wholly, or in part, at any time it may be deemed necessary, and agrees to provide under ordinary conditions other work at the regular rate of pay, for the apprentice during such period.

7.—Apprentices will be required to perform their duties with punctuality, fidelity and diligence, and to conform to the rules and regulations which are or may be adopted for the good government of the shop or the High School. The first two months of the apprentice's shop work are to be considered a term of trial during which either party to the agreement may, upon due notice, dissolve this agreement without prejudice.

8.—Lost time shall be made up before the expiration of each period, at the rate of wages paid during said period, and no period of service shall commence till after all time lost by the apprentice in the preceding period shall have been fully made up.

9.—The apprentice must purchase from time to time such tool as may be required for doing rapid and accurate work.

10.—Said term of approximately 4950 hours (three-year shop term) shall be divided into six periods, as stated below, and the

compensation shall be as follows, payable on regular pay days to each apprentice:

For the first period of approximately 825 hours, 10 cents per hour.

For the second period of approximately 825 hours, 11 cents per hour.

For the third period of approximately 825 hours, 12 cents per hour.

For the fourth period of approximately 825 hours, 13 cents per hour.

For the fifth period of approximately 825 hours, 14 cents per hour.

For the sixth period of approximately 825 hours, 15 cents per hour.

11.—This contract, subject to two months' trial noted in paragraph No. 7, shall be signed by the three parties to the contract at the time the boy enters the shop.

12.—The satisfactory fulfillment of the conditions of this contract leads to a diploma to be conferred upon the apprentice by the school board of Fitchburg upon his graduation and the surrender of this paper to the apprentice, bearing the signature of an officer of the employing company, certifying that the term of apprenticeship has been satisfactorily completed.

Agreement Between Three Parties

This Agreement, made the........day of..............A. D., 191..,
by and between..................of..........party of the first part;
(Employer)

and............................of........party of the second part;
(Apprentice)

and............................of........party of the third part.
(Bondsman)

Witnesseth. That the party of the second part shall, from the date hereof, for the term of three years (4950 hours, divided into six periods of 825 hours each, as stated in the "Rules and Conditions") and so much longer as may be necessary to make up lost time, become and be the apprentice of the party of the first part to the art or trade of ...., and that said parties of the first and second parts will well and truly do and perform all things required to be done and performed by them in and by said Rules and Conditions of the Co-operative Industrial Course.

And said party of the third part, in consideration that the parties of the first and second part have with his knowledge executed

this agreement, covenants and agrees for himself and his assigns, heirs, executors or administrators, with the party of the first part that the party of the second part shall well and truly do and perform all things required to be done by him, in and by this agreement, and in case said party of the second part shall in anywise violate any of the terms and provisions of this agreement or said Rules and Conditions, to pay to the party of the first part the sum of one hundred dollars, as ascertained and liquidated damages for such breach of contract.

In witness whereof, said party of the first part has caused these presents to be signed and sealed by ...., its .... for this purpose authorized, and said parties of the second and third parts have hereto set their hands and seals this day and year first above written.

Signed and Sealed..
(Employer)

In presence of..

Signed and Sealed..
(Apprentice.)

In presence of..

Signed and Sealed..
(Bondsman)

In presence of..

AGREEMENT OF RELATIVE OR GUARDIAN

I, ..., of the above named
(Relative or Guardian)

...................................do hereby give my consent to
(Apprentice)

his entering the employ of the said...............................
(Employer)

upon the terms named in the above articles of agreement; and I further agree that in consideration of such employment the wages or earnings of my said————shall be paid directly to him, and I
(Son or Ward)

hereby release all claim that I now have or may have hereafter thereto.

Dated at..........this............day of..............191...

Signed and Sealed..
(Relative or Guardian)

In presence of...

This is to certify that the within named.......................... completed his term of apprenticeship.

....(SEAL)

Uniform Apprenticeship Papers—Terms of Apprenticeship to the Foundry Trade

1.—Applications for apprenticeship will be received at any time, but will be considered solely on their merits, not in the order of their application.

2.—Three years' service will be required, except in trades requiring longer terms, from each apprentice, and each year shall consist of 2700 hours, divided into two periods of 1350 hours each. The first 750 hours of service shall be a term of trial, during which either party to the agreement may, upon due notice, dissolve the agreement without prejudice, and payment to the apprentice will be made at the rate of 10 cents per hour for the time only that he shall have worked.

3.—The wages of apprentices shall be as follows:—For the first period 10 cents per hour; for the second period, 11 cents per hour; for the third period, 12 cents per hour; for the fourth period, 13 cents per hour; for the fifth period, 14 cents per hour; for the sixth period, 15 cents per hour. Wages will be paid on the regular pay-days of the company as they may be from time to time established.

4.—Lost time shall be made up before the expiration of each period, at the rate of wages paid during said period, and no period of service shall commence till after all lost time by the apprentice in the preceding period shall have been fully made up.

5.—It is also expressly understood and agreed, that when, from any cause whatsoever, it shall become necessary to shorten the hours of labor, or stop the works, the aforesaid employing company may make payment only for the time actually worked.

6.—The employing company will furnish the apprentice work and supervision suitable and proper for him to learn the............ trade during the regular working time of its shop, until he shall have served three years of the number of hours above stated provided he shall comply with the terms and conditions of this agreement and show a reasonable capacity and ability to do the work given him. And the employing company also will faithfully instruct the apprentice in the...............................art and trade in their shops, in Fitchburg, during his said term of apprenticeship.

7.—Apprentices will be required to perform their duties with punctuality, fidelity and diligence, and to conform to the rules and regulations which are or may be, adopted for the good government of the shop; and the company reserves to itself the right to terminate the agreement and discharge an apprentice from further

service for any unfaithfulness, nonconformity with such rules and regulations, want of diligence, indifference to his business, incapacity, or improper conduct in or out of the shop.

8.—The apprentice shall take no other employment or occupation for his time during his apprenticeship unless permitted by the employing company.

AGREEMENT BETWEEN THREE PARTIES

This Agreement, made the.........day of..............A. D., 19..

by and between..................of............party of the first part;
(Employer)

and.............................of..........party of the second part;
(Apprentice)

and..............................of..........party of the third part;
(Bondsman)

Witnesseth. That the party of the second part shall, from the date hereof, for the term of three years (each year consisting of 2700 hours, divided into two periods of 1350 hours each), except in trades requiring longer terms, and so much longer as may be necessary to make up lost time, become and be the apprentice of the party of the first part to the art or trade of................., under and according to terms and provisions contained in the Uniform Apprenticeship Papers hereto annexed and made a part hereof and headed "Terms of Apprenticeship", and that said parties of the first and second parts will well and truly do and perform all things required to be done and performed by them in and by said "Uniform Apprenticeship Papers" and the provisions thereof.

And said party of the third part, in consideration that the parties of the first and second part have with his knowledge executed this agreement, covenants and agrees for himself and his assigns, heirs, executors or administrators, with the party of the first part that the party of the second part shall well and truly do and perform all things required to be done by him, in and by this agreement, and the Uniform Apprenticeship Papers herein referred to, and in case said party of the second part shall in anywise violate any of the terms and provisions of this agreement or said papers, to pay to the party of the first part the sum of One Hundred Dollars, as ascertained and liquidated damages for such breach of contract.

In witness whereof, said party of the first part has caused these presents to be signed and sealed by.........................
its..............for this purpose authorized, and said parties of the

second and third parts have hereto set their hands and seals this day and year first above written.

Signed and Sealed..
(Employer)

In presence of..

Signed and Sealed..
(Apprentice)

In presence of..

Signed and Sealed..
(Bondsman)

In presence of..

AGREEMENT OF RELATIVE OR GUARDIAN

I, ...of the above named
(Relative or Guardian)
..................................do hereby give my consent to
(Apprentice)
his entering the employ of the said..................................
(Employer)
upon the terms named in the above articles of agreement; and I further agree that in consideration of such employment the wages or earnings of my said...............shall be paid directly to him,
(Son or Ward)
and I hereby release all claim that I now have or may have hereafter thereto.

Dated at..................this...........day of........19..

Signed and Sealed..
(Relative or Guardian)

In presence of..

This is to certify that the within named.........................
completed his term of apprenticeship.

....(SEAL)

TERMS OF SPECIAL APPRENTICESHIP IN THAT BRANCH OF THE MACHINIST'S ART AND TRADE DESIGNATED IN THE AGREEMENT HERETO APPENDED

Application must be made in person. When satisfactory, the applicant's name will be registered and due notice given when he is required to commence work. Applicants must be at least seventeen years of age.

The apprentice must, before commencing work, execute, together with some responsible surety, an agreement in the form hereto appended.

A trial period of 240 hours will be first required, after which, should the apprentice prove satisfactory, he will begin his term of service, which will be computed from the beginning of the trial period. The wages of an apprentice during trial period shall

be the same as paid for the first six months of the branch herein specified.

If, during this trial period, an apprentice should, in the opinion of said Company, prove deficient in capacity or unsatisfactory in deportment, notice to that effect shall be given to said apprentice and his surety and the contract of apprenticeship shall become absolutely void.

Turning	1½ Years of 2700 Hours a Year.
	Wages—18c per hour first six months.
	Wages—21c per hour second six months.
	Wages—25c per hour third six months.
	1 Year of 2700 Hours.
Vertical	Wages—20c per hour first six months.
Boring Mill	Wages—25c per hour second six months.
	1 Year of 2700 Hours.
Horizontal	Wages—20c per hour first six months.
Boring Mill	Wages—25c per hour second six months.
	1½ Years of 2700 Hours a Year.
Planing	Wages—18c per hour first six months.
	Wages—21c per hour second six months.
	Wages—25c per hour third six months.
	1½ Years of 2700 Hours a Year.
Milling	Wages—20c per hour first six months.
	Wages—22c per hour second six months.
	Wages—25c per hour third six months.
	1 Year of 2700 Hours.
Drilling	Wages—20c per hour first six months.
	Wages—22c per hour second six months.
	1 Year of 2700 Hours.
Grinding	Wages—20c per hour first six months.
	Wages—22c per hour second six months.
	1½ Years of 2700 Hours a Year.
Erecting	Wages—20c per hour first six months.
	Wages—22c per hour second six months.
	Wages—25c per hour third six months.
	1 Year of 2700 Hours.
Turret	Wages—20c per hour first six months.
Machine	Wages—22c per hour second six months.
	1½ Years of 2700 Hours a Year.
Vise Work	Wages—20c per hour first six months.
	Wages—22c per hour second six months.
	Wages—25c per hour third six months.
	1 Year of 2700 Hours.
Scraping	Wages—20c per hour first six months.
	Wages—25c per hour second six months.

AGREEMENT

This agreement is made and entered into this............day of....................19.., by and between.......................
a corporation doing business in the city of Fitchburg, Mass., hereinafter known as the "Company,"................................of
............, hereinafter known as the "Apprentice", and...........
....................of...................., hereinafter known as the "Surety".

1. For the purpose of learning the trade of..................
..........................hereby becomes the apprentice to the Company, and the Company herein accepts said...................
as an apprentice in the trade of..
beginning on the......day of............, 19.., in accordance with and subject to the "Terms of Apprenticeship" hereto attached and made a part hereof.

2. And the said............................, as surety, hereby guarantees that the said Apprentice shall well and truly conform to, and abide by all the provisions of said "Terms of Apprenticeship", and shall in no way violate its provisions, nor shall he abandon said apprenticeship before the expiration thereof.

3. It is fully understood and agreed by the said Apprentice and his Surety that the Company shall have the right at any time to discharge said Apprentice for unfaithfulness and non-compliance with the rules and regulations of the shop, want of diligence, indifference to business, or improper conduct both in or out of the shop.

In witness whereof the three parties to this agreement, made in triplicate, hereto set their hands and seals, the day and year above written.

EXECUTED IN PRESENCE OF

APPRENTICE ....(L. S.)

SURETY ....(L. S.)

COMPANY ....(L. S.)

Wages will be paid on the regular pay days of the Company as they may, from time to time, be established. The sum of 2 cents per hour will be retained by the Company for the first year of 2700 hours, this sum to be forfeited by the apprentice should he fail to complete his contract to the satisfaction of the Company; but the same to be paid by the Company to the apprentice on the completion of his apprenticeship in a satisfactory manner.

Lost time shall be made up at the expiration of each year at the rate of wages paid during the said year, and no year of

service, or fraction thereof, shall commence until all time lost by the apprentice in the preceding year shall have been fully made up.

It is also expressly understood and agreed that at any time when, from any cause whatever, orders shall fall off, making it necessary to shorten the hours of labor or close the works, the said Company reserve the right to suspend the apprentices wholly or in part, making payment only for the time actually worked.

The Company will faithfully instruct the apprentice in their shop at Fitchburg, Mass., during said term of apprenticeship, in that branch of Machinist's Art and Trade specified in the agreement hereto appended.

Apprentices will be required to perform their duties with punctuality, fidelity and diligence, and to conform to the rules and regulations which are, or may be, adopted for the good government of the shop; and the Company reserves to itself the right, at its sole discretion, to terminate the agreement and discharge an apprentice from further service for any unfaithfulness, non-conformity with such rules and regulations, want of diligence, indifference to his business, or improper conduct in or out of the shop. In case of such discharge, or in the event that said apprentice shall abandon his apprenticeship before the expiration thereof without the consent of the Company, the apprentice shall forfeit all wages then earned and unpaid, together with the money earned during his apprenticeship to said Company.

Discussion

Mr. J. H. Holmgreen:—How does the shop pay these boys?

Mr. W. B. Hunter:—We pay 10 cents an hour at first and they are getting 15 cents an hour at the end of three years. I should say that in Massachusetts our school term is 40 weeks.

Mr. J. H. Holmgreen:—We have a high school and a manual training school, but it is so primitive it is laughable. The high school has a little cupola. They take off about three heats during the term. For several years the high school has been bringing the students through the works, but we find that plant visitation is a picnic more than any-

thing else. I am very much interested in this alternate plan, which appears to have great merit.

THE CHAIRMAN, J. P. PERO:—Gentlemen, this is a subject of vast importance to us as foundrymen. Mr. Hunter is doing a splendid work. We have got to realize, gentlemen, that the foundry is no longer attractive to American boys, to young men who are stronger mentally than physically. Now while foundry work requires physical strength, it also requires mental strength, and we will not have this mental strength unless we make the shop attractive to mentally strong men. If we cannot do this, our foundries are not only going to stop progressing, but are going to retrogress.

MR. F. G. STEWART:—I have always maintained that the greatest factor in producing competent tradesmen and good mechanics is the apprentice system, and that the Union on one side with its meager allowance of apprentices and on the other side the desire to specialize has made many changes in the foundry practice in the past 20 years. Under present conditions, it is certain we are not developing first-class mechanics in the foundry.

MR. A. L. WILLISTON:—Mr. Chairman and members of the convention: This problem of providing efficient workmen and foremen in our industry is one of such supreme moment and importance, that I have been glad of this opportunity which has been extended to me this morning to say just a word to you. I am not going to trespass greatly on your time. I do want, however, to call to your attention first a few simple facts in the history of the development of your industry. In the beginning of your industry in America, we saw almost exclusively the employment of American-born boys and American-born men. This material was developed slowly, it is true, but nevertheless surely, and in the end reached a high degree of practical intelligence. The men of this early generation that I am describing acquired skill from their fathers or men who had been in the business long enough to be able to instruct them and from men, too, who took an interest in instructing them.

As the manufacturing industries in this country grew, the supply of American-born help became small. There was a call for skilled foundrymen to come to America from across the water. At first that call was met by skilled mechanics from England and Scotland and things went well. In these older countries there were facilities for training workmen and the men who came from the British Isles in response to the American demand were, in the main, superior workmen, intelligent and well trained. But soon the supply of England and Scotland was exhausted too and we commenced to call on Germany, on Sweden, and on Norway. In those countries also there were schools and systems of apprenticeship by means of which workmen were trained and consequently we were able to get efficient men. It was not many years, however, before the supply from those countries was likewise exhausted. There was nowhere else to turn for aid and the ingenious men in this country were forced to set to work to see what they could invent in the line of labor-saving devices to develop a means of utilizing unskilled labor where skilled labor had formerly been used, and this in a measure made good the deficiency.

Changes Forced by Lack of Men

During the last two decades—perhaps a little more than that—change after change in methods has been largely forced upon the industry by the lack of skilled workmen. Up to a certain point this carried with it development and progress, but soon we reached a point where we needed the intelligence to supervise and direct work, and we found that there were no longer the young men from whom we could pick superior and dependable foremen and superintendents; and today there is almost a complete dearth of that kind of material coming forward.

You can yourselves trace this condition in your industry and compare it with conditions in other industries. Really, gentlemen, the situation is more pathetic than many of you realize. Some of you are still able to get along all right but you have not perhaps thought of what the situation is going to be eight or a dozen years hence. The draft that has just come

upon you this year has taken away numbers of competent foremen and superintendents and has taught some foundries, at least, that it is not easy to replace such men today.

America has done absolutely nothing to develop a system of training to produce men in any large numbers for your industry. The question I want to put up to you today is: What has the future in store for you in case somebody does not do something to prepare a plan, and to see that the plan is put in operation for developing a new generation of superior workmen, foremen and superintendents for this important industry? That is what we need. We have seen pressed steel and drop forgings taking the place of the products of your industry in many places. It ought not to have been allowed to happen and it was caused by lack of interest on the part of those in control of the industry. There has not been the proper development and advance on the human side in the rank and file in your own industry to balance the technical and mechanical advance. I don't believe there is a man in the room who would care to contradict that statement.

Skilled Crafts Become Professions

You have seen during this same period other industries change from skilled crafts to professions; you have seen applied science entering into them in a hundred ways; you have seen modern engineering coming in, to develop methods or processes in which the old rule-of-thumb man or the individually trained man could have no part. In such places he has become no longer useful. But contrast this with the condition of your own industries which at best only here and there under exceptional conditions and in a few departments has put itself upon a scientific basis.

Now I don't want to go into the details of what can be done in school. Enough experiments have been tried in systematic ways of training skilled workmen in your industry that are absolutely practical, but no system, no scheme for developing men in any industry or any period of the world's history has ever been effective until the rank and file of the profession or the calling became enthusiastic about that scheme, and

that is the thing that the foundry industry of America has not yet become. The superior workman in pretty nearly every calling you can mention has been developed in the main through the agency of organizations or guilds of one sort or another. They have always been responsible for starting such propositions; I believe always must be.

Develop Superior Workmen

Now the thing I want to put up to this association, if I have your permission, Mr. Chairman, is the idea of having the American Foundrymen's association get solidly back of this idea of having something done to develop superior workmen, foremen, managers and superintendents for the future, and I would like to suggest that you pass a resolution asking your executive committee to give this matter serious study during the coming year and see if it may not devise some kind of a plan by means of which the whole association, and the National Founders' association and the local foundrymen's associations, like the New England Foundrymen's association, may all co-operate and get back of this idea, and really do some effective work, and accomplish something. I would be very glad if some one who is a member of the association would make such a resolution so that it might be before this meeting at least for discussion.

MR. R. A. BULL:—I am very sorry, Mr. Chairman, that a number of our members are in the other room. I regret that more of our members could not have heard Mr. Williston's very true remarks. I am sure that all of us are interested, particularly now of all years in training men to be more competent workers but the difficulty about all those things is that it is hard to get a start, to produce any effective action. I think that Mr. Williston's suggestion is a very pertinent one and as a member of the association I am very glad to offer a motion, Mr. Chairman, to the effect that the executive board of the association be directed to make an intensive study, through any committee which it may authorize, of the matter of training of skilled workmen and apprentices and that the said committee be instructed to appropriate whatever sum of money

it may consider necessary for the furtherance of that investigation.

Mr. A. L. Williston:—I would like to make one simple addition. In urging you to pass such a resolution I have not intended to cast any reflection on any committee you have. I think you have an admirable committee; you have had a committee studying what schools might do through courses of training and that committee presented a report, I believe, yesterday. The larger question is what can be done to get every man in the industry interested in backing that program. You also have a conference board between this association and several other associations that are interested in similar work. I wish to cast no reflection on the work of that conference board, but it is important to do a larger work in organizing the entire industry to back whatever program is put forward. It is that larger question that was suggested in the resolution which the gentleman just made. The secretary has corrected me; he has informed me that as the institute which I represent is a member of the association, I did have the legal authority to offer the motion myself. I, therefore, now take pleasure in seconding Mr. Bull's motion.

The Chairman:—Gentlemen, you have heard the motion and have heard it seconded. Are there any remarks?

The motion was adopted.

Report of A. F. A. Delegate to Conference Board on Training of Apprentices

The Conference Board on Training of Apprentices is composed of delegates from six national associations, of which the American Foundrymen's association is one. Three delegates are appointed by each association. So far as I am aware, it has not been the custom for the delegates to make a formal report to the association since reports are made, from time to time, by the Board directly to the contributing associations. However, at the request of the chairman of the Committee on Papers, I am submitting the following brief statement.

Since the last annual meeting of the American Foundrymen's association, the Conference Board has held two meetings, one in September, 1916, and one in January, 1917. At these meetings the Board prepared, discussed, revised and finally approved Bulletin No. 2, entitled "Fundamentals of Apprenticeship". Copies of this bulletin have been distributed to the members of the association and the bulletin is, therefore, the best possible report to the Association.

It may be stated that the delegates appointed by the American Foundrymen's association have laid especial emphasis on the importance of seeking the co-operation of the public schools to the fullest extent possible in the training of apprentices. This attitude has been maintained without in the least overlooking or minimizing the duty of the employer in this particular.

In this connection we were able to influence the final form of the section on "Educational Fitness of Applicants for Apprenticeship" (see page 21 of the Bulletin), securing some recognition of the modernized school system wherever it exists.

Tentative notice has been given of a meeting to be held in September or October which I shall expect to attend unless advised to the contrary.

Frank M. Leavitt, *Delegate.*

Report of the A. F. A. Committee on Industrial Education

At the last annual meeting of the association the president was authorized to appoint a committee to study and to report upon the training of molders' apprentices. The committee was authorized to visit schools for the purpose of learning what courses had been developed for such apprentices and whether or not these courses were so satisfactory and effective that they might be recommended to members of the association. The members of the committee were as follows: Mr. C. E. Hoyt, Lewis Institute, Chicago; Dean C. B. Connelley, Carnegie Institute, Pittsburgh; and Frank M. Leavitt, University of Chicago, chairman.

After considerable correspondence and two or three personal conferences between the chairman and individual members, it was decided that it was inexpedient to go to the expense of visiting schools, at least for the time being, since the members of the committee were fairly well informed on the subject as it was. We knew what was being done in the public and private schools, and appreciated the fact that, with a few exceptions, little was being attempted that was actually reaching the young men who were already at work as molders, or who were likely to become molders. Most of the training was for the men higher up and, while such training would undoubtedly be of benefit to apprentices, little success was being made in actually getting apprentices to take the training.

Experimental Classes

It seemed to the committee that the greatest service it could render the association would come from the establishment of two or three experimental classes of actual apprentices, and in developing a course of study and practice for the apprentices that should have the approval of the employers themselves.

We also felt that such classes should be the result of co-operative action on the part of the employers and the public

school system. It was planned, therefore, to have the classes conducted under the auspices of the public schools without expense to the employers or to the association.

Through the good offices of Mr. Hoyt, preliminary conferences were held with a small group of foundry foremen in Chicago, and an interview was had with the school authorities. These conferences demonstrated the feasibility of such a plan. We expect to see the plan put into operation this year, but it has been necessary to wait until something quite definite could be done to secure a satisfactory course of instruction.

Since the appointment of the original committee, Mr. Stewart Schrimshaw, supervisor of apprentices for the state of Wisconsin, has been added. This was done at the request of the committee because it was believed that an experiment might be worked out in that state also. It is possible that, through the assistance of Dean Connelley, an experimental class may be organized in connection with the public schools of Pittsburgh.

All this has taken time and the committee can only report progress. However, some definite steps have been taken. For example, the committee has been assured by the director of vocational work in the Chicago schools that he will establish the courses for which we have asked whenever we will submit the course of instruction and provide the apprentices. The foremen assure us that they will do all in their power to assist in developing the course and in making arrangements to have apprentices take the work.

Thus far the committee has not drawn upon the sum appropriated to defray expenses.

FRANK M. LEAVITT, *Chairman*
C. E. HOYT
C. B. CONNELLEY
STEWART SCHRIMSHAW

Facilities for Technical Training at Massachusetts Institute of Technology

By John Ritchie Jr., Boston

Foundrymen and others in the metal industries will find a great deal to interest them in the laboratories and courses of the Massachusetts Institute of Technology, Boston. Of closest connection to the work of the metal trades are the laboratories in mining and metallurgy, the forge shops, the machine tool laboratory and the laboratory in electro-chemistry. Incidentally geology and especially economic geology are of interest as fundamental studies, but it is my intention now to consider the four specialties first-named.

First, it is in place to state that in none of the laboratories has there been greater betterment in point of space and equipment through the recent removal to the new buildings than in the department of mining and metallurgy. In the old buildings on Boylston street, this work was done in the basement of the Rogers building. The equipment was crowded, the class rooms rather inconvenient, the library huddled into a corner which was in part used for offices, while certain of the rooms were interior ones with no light or air from the outside. The offices of the instructing staff were encumbered with material for the museum and for the past few years it has demanded patience on the part of the teachers to accommodate themselves to the inconveniences that had been evolved.

At the New Technology, a special building for the department of mining and metallurgy lagged somewhat behind the general construction, but in June, 1915, at the celebrated Telephone Dinner of the alumni that crowned the ceremonies and festivities of the dedication of the new structures, President Maclaurin announced that sufficient funds, about $300,000, had

been given by the Du Ponts, Coleman and Irenee, and Charles Hayden, to ensure the speedy erection of the proposed structure. In a little more than nine months the mining and metallurgical wing was ready. It was necessary to continue instruction in the old laboratories for only a single term.

The New Technology

The New Technology may be roughly described as a vast building surrounding on three sides the great court (365 feet to a side), as well as three sides each of two minor courts named after Augustus Lowell and Coleman duPont. The latter are extensions to left and right of the great court. Across the head of the large court lies the library building with its dome, and to left and right of it as one views the structure from the Esplanade along the axis of the court, are the administration and electrical wings. It is in this line and farther to the right of each that the mining and metallurgical wing is situated. The entire space of over 200 feet in length and four stories in height, with a basement which is really above grade, is with the exception of a few offices devoted to the work of the department. Altogether this area measures about 12,000 square feet to each floor. There are large laboratories, well lighted offices, spacious corridors, excellent class rooms and many other rooms for museum, library, research work, storage and the utilities. Here the treatment of ordinary ores and metals is studied. In another department, that of electro-chemistry, the electrical furnace is employed. That such furnaces are not installed in the mining and metallurgical building is due merely to the fact the other department was already equipped with such apparatus, and in the interests of economy it seemed unnecessary to duplicate such costly machinery. As in all the departments at the institute, the laboratories are maintained for all of the students, and the metallurgical men are as much at home in the laboratories of electro-chemistry as are the men taking this special subject.

In the laboratories of mining and metallurgy and those of electro-chemistry the student studies the various methods of ore dressing, smelting, etc. Next in order comes the general shaping of the metal for which well equipped forge shops are pro-

vided. They are in a building quite distant from the rest of the educational plant, some 700 feet to the rear, convenient to the railway tracks.

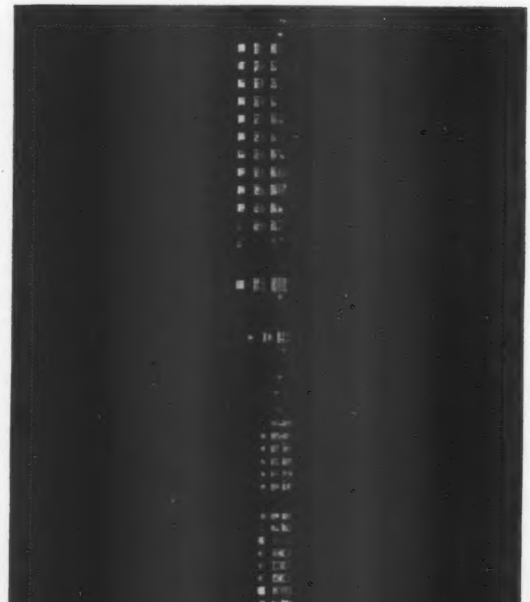
For shaping metal after it has been given its rough general form, the institute has a great floor set aside for the machine tool laboratory. It is fitted with all kinds of devices for working in iron, steel or other metals. Some 25 lathes are provided, together with millers, grinders and other accessories. Turret lathes, planers, and tools for handling materials are installed, together with a tool room stocked and precision instruments for delicate measurements.

Learns by Doing Things

Here as elsewhere in the Institute the student learns by "doing things". He has a perfect lathe which, with the necessary tools, is his for his period of work, and under the direction of the head and his assistants, he is given practice in the fundamental operations that make the metals of their highest use to man. Turning, grinding, tapping, thread-cutting and other mechanical processes are carried forward by the student, not in a weary repetition, but in a broad scheme that gives to him the underlying principles. Then from the lathes the student goes to more complicated, automatic machinery, precisely the machines that will be found in any up-to-date shop. Accuracy to 0.00005-inch is required of the students. The young man who spends his time in this laboratory carries away with him not only a good technique, an automatic handling of the more common operations, but a splendid grounding in principles.

Incidentally related operations like heat treating and tempering, in fact, everything that relates to the handling of materials—which by the way include woods as well as metals—come to the student in a form suited to instruction and in logical order, so that his acquirement of knowledge is scientifically built up.

Not only does the student thus carry on his work under the eye of instructors, but in well arranged little auditoriums, where the tiers of seats circle about the machine in the center, he gets from the instructor the philosophy of handling the complicated, modern devices. Skilled industrial experts are



MASSACHUSETTS INSTITUTE OF TECHNOLOGY AT NIGHT

frequently called in to demonstrate modern methods, such as electric and oxyacetylene welding.

At the New Technology, the experience of 50 years dealing with the requirements of education has led to the construction of buildings which even below the foundations have been especially adapted to the needs of laboratories and teaching. In mining and metallurgy there have not been required such special features as in the field of hydraulics, for example, where 700 feet of waterways were placed with a number of deep and capacious wells, but the needs of the metal trades have been remarkably cared for within a building harmonious in design and proportions with the others in the great technology structure. Thus it is that the fire metallurgy laboratory extends up through two stories, while the ore dressing section presents a succession of half stories, giving opportunity for the employment of a series of gravity processes.

The larger laboratories of the metallurgical department of the institute include: Fire metallurgy, ore dressing, crushing and sampling, wet metallurgy, fire assay, wet assay, metallography, heat treatment, mechanical testing, together with an iron and steel laboratory which presents opportunities for rolling and wire drawing. Each of these halls is elaborately fitted up with equipment for the study of the fundamental principles of the special work in hand and types of the different machines employed in the various processes. The student has the opportunity to make comparisons and these will include all the kinds of apparatus that are in general use, to say nothing of the various devices invented by Professor Richards or others to illustrate principles.

A Model Blast Furnace

In the great 30-foot high hall that serves for the laboratory of fire metallurgy, there is a typical blast furnace, specially made and small in size, but competent to carry out commercial-sized operations. It occupies one end of the laboratory which is furnished with a gallery from which the furnace may be charged conveniently. Ranged along the brick floor are nine or ten other furnaces of various types. These include the American and Monarch gas furnaces, a Bruckner roasting

furnace, a Wedge roasting furnace, small and large reverberatory furnaces, a desilvering furnace, a copper converter and a furnace for cupelling and copper refining. Quantities of accessories, slagpots, trucks and the like are at hand. In a little room opening from the main laboratory are half-a-dozen or so small gas furnaces and in another little room, devoted to compressors, there are two types of machines, electrically driven, including an Ingersoll-Rand compressor and a Connersville blower. The laboratory, which is in the basement and first story of the building is splendidly lighted by long windows having a north light. An elevator near the doorway from a driveway, serves the gallery of this laboratory as well as the ore-dressing rooms and the upper halls of the building.

In the crushing and sampling room close at hand and on the first floor of the building there are ten or more machines of almost as many types. There is a Braun planetary pulverizer, a Braun disk pulverizer, a Case crusher, a Farrell crusher, a Sturtevant crusher, and a McCully rotary crusher; there are Sturtevant rolls and Allis-Chalmers rolls, pebble mills, a Sturtevant shaking screen and screens of many different meshes.

The ore-dressing laboratory is located on two floors of the building, the ground plan covering about 2000 square feet. It is peculiarly planned for its uses, having half-stories on both floors, making four levels which are interconnected. The different levels are available for processes in which gravity is employed.

Stamp Mill

The highest level is used mostly for storage and on the floor immediately below it stands a 2-stamp mill whose output may be run to the floors below. On the same level are placed a trommel screener for lead work, several Wilfley tables and a Richards pulsating jig. On the half-floor below are a Johnston concentrator and two jigs, one of the Lake Superior pattern and the other a Hartz machine. On the lowest level the equipment includes two magnetic separators, the Wetherell and the Ball-Norton, the big, round M. I. T.-made slime table, a canvass and a Wilfley slime table, two Wilfley tables, an Embery vanner, and a variety of smaller devices, ball mills, etc. Here

as well as in the story above a series of slime tanks is set below floor level. On one side are free-settling and hindered classifiers, nearby a vibrating table. The various flotation outfits, Hyde, Janney, Case and Callow, with agitators, drying pans and the usual accessories of such a laboratory also are provided.

In the laboratory devoted to wet metallurgy may be found a set of Washoe amalgamation stands, electrolytic vats, electric furnaces of small capacity, cyanide percolation vats and other items like bottle agitators, filter presses, pebble mills, etc.

One of the great rooms above the ore-dressing laboratory is devoted to fire assay. Here is one row of Denver brick furnaces for soft coal, six double units in all, with 24 muffles. Two sets of six pot furnaces flank the larger ones. Twin and single oil furnaces also are provided.

One floor above is the metallographical laboratory, with its equipment of microscopes, leading from it a polishing room. Nearby is a laboratory for iron and steel with gas furnaces and forges, while between the two is the testing laboratory.

For the department of mechanical engineering a series of halls have been set aside and equipped with apparatus for testing materials. But for the convenience of the department of metallurgy a small laboratory is located within its own wing. It is equipped with a universal testing machine of the Riehle pattern of 100,000 pounds capacity, a Brinnell hardness tester and other apparatus.

Faculty of the Institute

The teaching staff in this department includes nine professors and assistant professors, an instructor and two assistants. The courses are interwoven with those in physics, chemistry, mineralogy, geology and the applied sciences so that the student is given a broad foundation.

The institute has always fostered research work to the limit of its abilities, and many students in past years have come from distant countries, notably Russia, South America and Japan, to pursue advanced work in science. It also has been President Maclaurin's constant endeavor to keep the institute in close touch with the industrial world.

How Character Analysis Solves the Man Problem

By WILLIAM JUDSON KIBBY, Cleveland

This is an age of specialization, when men must be trained carefully for one specific line of endeavor. The past 35 years has been called the "machine age". The inventive genius of the world has been so concentrated upon the problem of producing merchandise by means of machinery, that the mind of the average man cannot comprehend the magnitude and complexity of the machine. We have just awakened to the fact that this complicated machine and system is good only in so much as the men back of it are good and right. Therefore, we are turning our thoughts to the man problem; we are finding that if the man is right, the problem takes care of itself; but when the man problem is not right, we are at sea.

Look at Marconi and the wireless, Mergenthaler and the typesetting machine, Madam Curie and radium, Maxim and the silencer, Wright Brothers and the flying machine, etc. All of their accomplishments are the result of specializing upon one idea, aided by science.

Science

Herbert Spencer has said, "Science is organized knowledge, correlated and tested truths, classified common sense." It is stated on good authority that in the past 25 years more wealth has been added to the world than in any previous century, and this has been accomplished because of "Science". We are organizing our knowledge more perfectly. The principles of aviation, ether waves, etc., have existed since the beginning of time, but we are just learning to see and use them in a broader and more effective way.

As a result of science, we are going to know the efficiency value of an individual before employing him. We are going

to know his physical fitness and his mental equipment. We will not content ourselves with the study of man in the abstract. but we will study him in the concrete, the practical. First of all, we will study the individual as to his mental and physical fitness, and not take him in bulk. Secondly, we will draw out his talents and not merely fill him in. Thirdly, we will find his dominant brain forces and place him accordingly. Fourthly, we will place him under the proper foreman; for it is not enough to place the right man on the right job, but it is necessary to place him under a foreman who will develop him. It has often been found that a wrong foreman has been the undoing of the right man on the right job. Fifthly, we will harmonize and team-up the right man on the right job under the right foreman and under the right working conditions, with the result of a maximum of efficiency and pay.

In the matter of cost pertaining to machinery, merchandise, labor, etc., we demand perfect knowledge; in other words, we are very scientific in the running of our business, for we find that we cannot succeed unless we operate our business upon a scientific basis, *i. e.,* organizing our knowledge pertaining to our business. In the face of this truth, why should we go on blindly employing men with no regard to their fitness or efficiency? The time has now arrived when industry demands to know more about this problem and it has set its face toward it with a grim determination to master it at all cost.

What Our Faces Tell

We turned our faces one winter afternoon toward the orchard. A naturalist had taken us in hand to show us the extent of his orchard. He laid before us figures showing the bushels of apples, pears, peaches, etc., which he had gathered the previous summer and fall. As we neared a group of small, slender trees, he said, "These are cherry trees," and he told us the kind of blossom and leaf the tree would bear in its season, also the color and size of the fruit.

He next called our attention to another group of small trees which we were told were crabapple trees—to us both

groups seemed alike, and very little difference could we find in them, because we did not understand tree life. He told us that one bore a very sweet, juicy fruit; while the other, a very tart fruit, but very much the same in size. He showed us another group of trees, and told us that they were June apple trees, and again described to us the nature of the fruit, the leaves, etc. Close beside these was another group of trees, which he told us were Horse apple trees. To us these last groups of trees looked alike. He hastened, however, to assure us of the great difference in the fruit they would bear. Of course, we took his word for it, because we did not know. To the man who understood the trees, they cried out to tell him what they were and he could tell what fruit they would bear in their season.

If trees, apparently dead in midwinter, can cry out to tell what they are, how much more so do our faces cry out to tell what we are—if we only knew.

He next took us to the barnyard to give us a little test; and after fastening a handkerchief over our eyes, he had us reach with our left hand and touch an animal, and as we felt its back and hair, we quickly drew the conclusion that it was a hog, because of the leathery skin and wiry hair. Immediately there ran through our mind the fact that this animal lived very close to mud and filth. Next we turned with our right hand and touched another animal, and as we stroked its back, we found softness and pliability. The texture of the hair was soft, and so was the flesh soft and yielding; so we determined that this was a sheep, and therefore, knew that the sheep lived in an entirely different atmosphere, a cleaner atmosphere than the hog; that it had an entirely different temperament. Now what has this to do with character analysis?

We are learning that there is just as much difference in the lives of men as shown in the texture of their hair and flesh as there is difference between the sheep and the hog.

In the early days of civilization men learned quickly to use sharpened flint to kill with, and therefore they knew that articles which were blunt would not penetrate, and articles

which were sharp would penetrate. We find a wide difference in the rapidity of the thought and action between sharp and blunt faces.

As a Man Thinks

King Solomon said, "As a man thinketh in his heart, so is he." And may we add, that that which a man thinks in his heart, writes itself upon his face. Our thoughts do write themselves upon our faces. They are indelible and express themselves in little physical manifestations so that those who are thinking honest, agreeable, generous, kindly thoughts have that kind of face. Those who are thinking dishonest, selfish, greedy thoughts, have dishonest, selfish, greedy faces. Those who are timid and cautious, have timid, cautious ways and faces. Those who have great physical energy, driving force, express such thoughts; and those who are cunning and foxy, have cunning, foxy faces.

Take, for instance, the squirrel with his timid, quivering lips, as we see him perched, sitting upright. Here it is we see timidity, cautiousness and nervous excitability. Then take the St. Bernard, with his steady gait and physical force. In him do we see steadiness, force, perhaps initiative, one not easily drawn aside from the purpose at hand. We can learn from the study of the animal much which will help us with human analysis. Do these thin and thick lips, thick lower and thin upper lips mean nothing?

Those mouths with the corners turning downward, do they express nothing of melancholy and the lack of hope? Do these mouths with the corners turning upward have no significance as to optimism? The big eye, the little eye, the steady eye, the cautious eye, the restless eye; coarse, fine or rough texture; loud or modest clothes and ways; do they not express something? The thin nose, flat nose, long nose, short nose, baby nose; the high forehead, the low forehead, the broad forehead, the narrow forehead; the broad chin, the sharp chin, the narrow chin, the long chin; do these characteristics not tell something? They do manifest the life back of them. The anatomist will take the scale of a fish, and by a study of it, accurately tell us the kind of a fish the scale came from, the nature of it and the number of bones, muscles, etc. When the

bone of an animal is placed in his hand, after a study, he will tell us the kind of animal it came from, and fully describe its characteristics.

The Need of Analysts

The question was asked of one of America's greatest executives as to what he thought was the greatest weakness of the coming executive, and he, after careful thought, came back with this answer: "The lack of analysis." The average individual cares little or nothing about analyzing and finding the whys and wherefores of the things he seeks to accomplish. In other words, he will not seek to find the units of the analysis; or after having found them, to carefully weigh each one; or after having weighed each unit, to place it back into the whole, thus getting a clear picture of the idea or thing from a wholly disinterested or unprejudiced standpoint. The age in which we live demands that individuals in pivotal positions, which call for opinions and judgments based upon fact, be analysts; and no one of ordinary intelligence will doubt this assertion.

First of all, we must analyze ourselves; and the greatest benefit possible from this study will come to the individual who sets out conscientiously to apply the analysis to himself, to find out what his weaknesses are. Then, with the aid of this analysis, he can find out what combination of faculties or habits constitutes the cause of any given weakness or weaknesses, and why. It is then easy to set out to eradicate the cause.

Get at the Cause

One winter evening a physician called at a home to examine a child who had been ailing for ten days. Upon examination of the lungs the doctor discovered that the lower lobe of the left lung was congested, and that the child was contracting pneumonia. Immediately the doctor gave orders for certain things to be done, certain medicine to be administered, saying that if he could remove that slight congestion, the boy would be up in four or five days. The directions were followed, and the boy was soon out of bed.

Anyone having looked at the child would quickly have realized that he was ill; the family knew it; he knew it; but

what they wanted to know foremost, was what was causing the boy to be ill.

Everyone of us has weaknesses, and our friends all know many of them. Our family and we know them; but there is not one person out of ten thousand who really knows what combination of habits or brain developments are causing his weaknesses.

This study sets out:

First.—To teach the individual how to analyze himself and to find out the cause of his weaknesses.

Second.—To tell how to analyze others.

Third.—To explain the application of these principles to everyday practical life, rather than in the abstract.

Need of Educating the Employe

Many of the most brilliant and capable systematizers and efficiency experts have failed, or at least have not had universal success in applying their methods because they have almost wholly neglected one of the most important factors of a successful program—that of educating the employe.

Some of our largest corporations have schools where their people may study to make themselves more efficient, and their value has been proved beyond a shadow of doubt, especially where they have been conducted by capable, practical individuals. The establishment of an employment plan such as we outline must be preceded by an educational campaign with every pivotal individual, foreman, head of department and manager connected with the institution—for each one is a vital unit and can be of assistance in working out the problem.

We will not deal with the principles involved in educating the employe along mechanical lines because efficiency, health, hygiene, sanitation, etc., have been ably treated by men who have made a life study of these problems and know more about them, perhaps, than we will ever know. But we will deal more with the methods involved in educating the employe so that the employment scheme will do its best work.

Methods

First, our experience has brought forth the truth that department heads should be educated through plain talks and helps in character analysis in the form of practical books.

They should become fully acquainted with the theory and its practice; and if these talks given to them are generated with the proper spirit, these pivotal men will all want analyses of themselves, which will help them in their own problems. At any rate, the knowledge they gain from plain talks on character analysis and its applications to their department, will enlighten them to the extent of working with intelligent co-operation rather than by blind alley methods. They will be in sympathetic accord with the movement, for they will have been imbued with the proper spirit underneath this great problem—*that of helping every individual to find his or her proper vocation in life.* With this as an ultimate end, to bring about co-operation, not in the spirit of charity, but in the spirit of genuine business efficiency and team work is not difficult.

The necessity for this preliminary work cannot be overestimated, for the very success of any employment scheme would be discounted to a large degree, and perhaps frustrated, if these individuals were not properly trained and imbued with the right spirit. Such meetings, or conferences, would result in bringing forth and working out the many complex problems which will forestall many elements of discontent in the office and factory. To the practical mind this is obvious, and needs only to be mentioned.

Secondly, practical talks should be given to the foremen, so that they, too, can become imbued with the proper spirit and knowledge of the employment system. They are more directly concerned with the employment plan than any other individual in that they come in personal contact with the employes. They should be analyzed so that they may be strengthened in their weaknesses; and it will certainly make them more in sympathy with the other individuals when they set out upon the great task of trying to master themselves.

We might state, very emphatically, that we do not approve of analyzing an employe by anything but a voluntary or semi-voluntary method. We do not believe, as a whole, that the analysis of employes will be nearly so helpful as when they are led to desire the analysis; and if the proper method is used they will desire such analysis, for it is a natural craving, a

most natural desire of the human heart, to want to know how to improve oneself.

How to Make Foremen's Meetings Effective

A method found to be effective with such meetings with foremen, has been to have a banquet or simple dinner, at which time the men would enjoy social intercourse, forget shop, shop methods, etc., and bring out the social side of their natures. The employes should not be required to pay for such dinners. In some instances old-time songs have been sung at the table, and some of the managers or officials of the company have been present and joined in making the evening a success with short speeches. Then the program has ended with a plain talk on scientific employment plans, methods, etc. Such meetings should be held not less frequently than once a month, or perhaps semi-monthly. Thus, during a period covering a number of winter months, the foremen have become acquainted with the company's employment methods and have, in the meantime, been given an opportunity to apply them in co-operation with the service, labor or employment analyst.

It is the common belief of the average foreman that he is compelled to use whatever material is sent him, and many of them fear to express their opinion as to the value of an employe. Such an attitude of mind causes retrogression and develops a "don't care" spirit which is one of the most crushing and killing influences possible. The foreman should be led to understand that there is no desire on the part of the institution to spy or to use the analysis of their men, except in trying to help them, and in undertaking to develop them. If such a campaign is entered into with only the letter and not the spirit of co-operation and team work, it is evident that it will not work. It ought not to work, for in principle it is wrong, and an institution that carries out any such policy, or permits it to be carried out, consciously or unconsciously, had better save itself any expenditure of time or money on the plan, for it will bring a poor result and may do injury. So it is evident, on the face of it, that the efficiency and effectiveness of any ployment plan is dependent to a large degree upon the spirit of the brotherhood of man; the administering of the

spirit of co-operation by every official, departmental head, foreman, subforeman, etc. For, if the spirit of co-operation is not generated from the top, it would be exceedingly difficult (if such officials come in vital contact with employes) for this employment plan to be successful.

We may be pardoned for our persistence in apparently harping upon the need of consistent and persistent spirit of co-operation, but we have often found some erratic officials, managers or department heads who will undo in an hour or a day more than a hundred loyal men can build up in six months. So that no effort should be spared in converting the pivotal heads to see the need of this phase of the educational employment plan and of their contribution to it.

Furthermore, regular meetings of foremen would also become a clearing house for ideas—not alone upon educational and employment work, but ideas upon manufacture, short-cuts, etc. The employment analyst would discuss with the foremen the various individuals sent to them since the previous meeting, and reports would be made upon various new employes who seem especially efficient or deficient. These reports from the foremen would give the employment analyst an opportunity to study the employes producing a minimum of work and poor in quality; individuals who on certain days rise to higher degrees of efficiency than on other days also could be examined as well as those who seem to fall below their regular production during certain hours of the day. Of course, this would be done without the knowledge of the employe. The analyst can discover this by tactfully questioning the individual in his office; or other methods would be pursued according to the needs of the individual case.

No doubt some persons reading these words will laugh; but when they laugh, they laugh without knowledge, because some of the most profitable institutions in the world have given great thought to this phase of employment work and have, by guarding against many of the possible obstructions, increased greatly the value of the individual in their production.

The foreman should be imbued with a practical knowledge, and above all, should have a sympatheic understanding of what is being done and the end being sought; he should not feel

helpless in working with an employe who might be very efficient, and yet wholly antagonistic to such a foreman.

Such meetings would bring about a readjustment of such an employe, perhaps resulting in replacing him under another foreman who would be more congenial.

These meetings would also tend to eliminate personal prejudices which exist more or less among foremen, for the employing analyst would readily detect these flashes or even looks and seek in a tactful way to draw these individuals together to their mutual benefit and the benefit of their work.

Thirdly, we will not alone analyze, but we will classify and memorize, in somewhat the following manner:

1.—The duties of the foreman, and the qualifications, both mental and physical, necessary to fulfill them will be considered.

2.—We will standardize the position by mapping out the necessary qualifications.

3.—We will chart the mental and physical characteristics of the individual possessing the right qualifications.

Fourthly, we will study every operation in the plant from the beginning to the completed product. From this we will learn:

1.—The number of operations and how strenuous, delicate, etc., they are.

2.—The mental and physical qualifications of an employe to fill specific positions.

3.—The mental and physical characteristics of the individuals possessing these qualifications.

The Relationship of the Engineering Department to the Pattern Shop and Foundry

By F. J. McGrail, Warren, Pa.

The primary object of this paper is to call attention to the necessity of the closest co-operation in a manufacturing establishment between the engineering department, the pattern shop and the foundry. In some places ideal team work exists in these departments, but it is a lamentable fact and a sad commentary on some of our industrial plants, that co-operation is conspicuous by its absence. Many departments are continually working at cross-purposes, when, if a closer relationship existed, costly errors in design, and improper methods employed in the construction of patterns and core-boxes might be eliminated.

In any successful industrial plant the spirit of co-operation enlivens and animates the entire institution, and the success or failure of the enterprise depends largely upon the willingness of the engineering department to "rub elbows" with the pattern shop and foundry. Executives who are imbued with a spirit of earnest fidelity to duty, an unswerving desire to do the right thing, and to do it always with animation, courtesy and good cheer, are towers of strength to any organization.

If the chief engineer, or his assistant, and the executives of the pattern shop and foundry department, would do more preparedness work, we might confidently anticipate the time when their united efforts would make a better showing on the right side of the ledger. It is not the intention to unjustly criticize or condemn what has been done by engineers in the past regarding the various and freakish designs of the many types of castings, especially gas-engine cylinders. The foundry is often called upon to solve many difficult and expensive problems, which, if a little foresight were used might often

be avoided. The writer believes that there are certain things to which reference should be made without hesitation, because they constitute some of the embarrassing details which are costly to the manufacturer and consumer alike.

There exists at the present time a serious lack of mutual understanding between the executives of these departments, and although considerable effort has been made to secure more harmonious working relations, the situation leaves much to be desired, because too little importance is given to a careful and systematic analysis of the work in the engineering department before it is sent to the shops.

Foundry Advance Has Kept Pace With Demand.

It must be admitted that a large proportion of the complaints made by the foundrymen are not always just and equitable and your kind permission is asked to digress a little here, to most emphatically deny the assertion that "there has not been the same advance in foundry practice that there has been in the demand made upon the foundry". In contradiction to the above claim, the writer emphatically contends that the foundry has in the past, and will continue in the future, to keep pace with the demands made upon it.

In most of the foundries of any importance, men will be found at the head who are equipped with the necessary mechanical and metallurgical information to enable them to handle any kind of work successfully and profitably. It is true that all of the products of the foundry are better now than ever before, and the conditions under which they are produced and handled are improving rapidly. A vast amount of research work has been done in many of the foundries to find and remove the many causes of defective castings, and many foundrymen with whom the writer is acquainted have made special efforts to advance themselves in their chosen profession, in order to establish the foundry on a higher plane than it has hitherto occupied.

What is Co-Operation?

The engineer, in planning his work, studies out a machine in which all the parts are to work in unison to produce a given result. In doing this, his work is thought out along fixed

mechanical lines, and he knows in advance how each mechanical movement will accomplish its intended purpose. The power of the machine to do a definite amount of work is almost an absolute certainty. There comes a day when the machine is tested. Each pulley, lever and gear does the amount of work allotted to it. This is co-operation of *inanimate* parts in its fullest sense.

Books are written, sermons are preached, and the silent drama is used daily to teach a lesson of some kind. The lesson it is desired to teach—the point it is desired to put through and clinch—is that if the engineering department would cultivate the habit of consultation and co-operation with the pattern shop and foundry, a smoothly running machine of *animate* parts would surely result, as the men who are working as parts of one harmonious unit should be given a certain amount of latitude in which to develop their power of initiative.

The writer confesses to some hesitation in making the foregoing suggestion, lest his motive be misunderstood. He does not wish to interfere in any particular with the engineer, but as the latter's work is largely theoretical, while that of the foundry is intensely practical, it has often been experienced that it would be more satisfactory and economical if the metal sections of some castings could be changed while on the drawing board, provided, of course, it did not affect the general result. Conferences would obviate many of the costly changes which it is sometimes necessary to make on account of disproportionate metal sections and design, and the many incorrect methods of constructing and assembling patterns and core-boxes.

The foundryman respects and admires the engineering profession. The standard of industrial intelligence is usually high, but the industrial battle is not won by the skill of the engineer alone, however eminent he may be. The engineer should obtain full and lasting credit for originating, but the results of his plans are brought out by his fellow workers in the pattern shop and foundry, whose standard of intelligence is assuredly high enough to bear their share of the industrial burden. The 20,000-horsepower turbine, or the machine which printed this page, would never have reached its present stage of efficiency without the assistance of the engineer's co-workers,

all absolutely necessary to each other. The sooner this is realized the better it will be for all concerned.

If the writer were asked to name the one qualification most needed in the engineering service, he should unhesitatingly say: "Consultation and planning with other executives." Innumerable instances might be given where financial loss might have been averted if a little planning were done. One case may be cited as an example of bad practice, due to a lack of consultation and co-operation.

The writer has in mind the figures of a skilled and thoroughly competent engineer of a large industrial plant, who estimated the cost of a certain type of casting at say $25.00 for material, labor and burden. A contract was made for 600 castings at this price, 50 castings to be delivered each week after the receipt of the pattern and core-boxes. This job was brought to the writer's attention about 10 days later when the pattern and core-boxes arrived accompanied by a letter asking that a special effort be made to ship 60 each week instead of 50 as the original contract called for.

Then the trouble began. No equipment was available for the job, the pattern and core-boxes were not made on mechanical principles, and could not be mounted on any of the available molding machines. A new pattern was made, the core-boxes were altered to suit, and work was immediately started on new equipment. Four weeks later, instead of one, as had been promised, shipment of castings began. However, only 30 castings could be produced per week instead of the 50 as called for in the contract. The cost exceeded the selling price, and the customer lost several sales on account of deferred deliveries, both sides losing heavily on the transaction because a get-together spirit was not in effect. When the engineer was asked for an explanation, he said that other work of a similar nature was going through the shop, and that he obtained the cost of it from the bookkeeper.

The Need of Co-Operation

The writer doubts very much if there are any other mechanical trades in which so many new and difficult problems are continually coming up for solution as in the pattern

shop and foundry. If there is any condition in which a hearty co-operation is needed in any industrial plant, large or small, it is between these two departments. The personality and temperament of the men in charge of the pattern shop and foundry, means much in dollars and cents in the course of a year to the firm employing them, and if the executives in some manufacturing plants would make as much effort to co-operate as they do to prevent co-operation, the industrial millenium would have been here years ago. The writer inclines to the opinion that the lack of intelligent co-operation causes American industries to lose millions of dollars every year.

The man in charge of the pattern shop and his associate in the foundry department are chiefly concerned with their labor costs, but this does not necessarily imply that a low labor cost of production in the pattern shop means an economical cost of production in the foundry. The methods employed in the construction of patterns and core-boxes to suit the equipment in the foundry, or other changes which might be easily made to facilitate a more rapid output of castings, are important factors in determining economy. If a slight increase in the cost of a pattern will largely decrease the cost of molding and coremaking, it is safe to assume that the extra outlay is warranted, as it contributes much towards a better feeling between the two departments.

In some plants, where the need of co-operation is understood and appreciated, conferences are usually held by the production manager and the executives of the pattern shop and foundry regarding the best method of handling the work. If only a few castings are needed, as frequently happens, a cheap pattern is recommended but if a considerable number are required, the cost of mounting them for a molding machine is figured carefully against the cost of hand molding, and the method showing the greatest gain is adopted. These conferences require but little time for consultation, and the benefits derived from them are manifold, as the most difficult problem we have to deal with today in the average plant is how to bring about a willing and sustained co-operation between the pattern

shop and foundry. The necessity of a co-operative spirit can be better illustrated by the following incident.

The proprietors of a large industrial plant in a middle western city engaged a foundry superintendent who had won a widespread reputation both as a foundryman and as an organizer. He threw himself heart and soul into his new work and made many radical changes which insured better castings and a greater output. At a meeting of the department heads held in the office of the general manager, he asked for and was assured of their hearty support. Co-operation, however, did not materialize as promised. Before many weeks had passed, the foreman of the pattern shop, and the foundryman, disagreed over some trivial matter regarding the size and taper of core-prints which were being attached to a new pattern. While the subject was under discussion, the patternmaker lost his temper and informed the foundryman that no "sand rat" could teach him anything, that he didn't learn his trade in a correspondence school, and so on and so forth. As a consequence of their quarrel, they studiously avoided each other for several months, and it eventually resulted disastrously for both parties. News of the discord in the two departments finally reached the ears of the general manager, who was a man of much action and few words. One day he summoned them to his office and said, "It takes two to make a quarrel, no explanations are necessary. You could not get together, now get out!"

The foundryman certainly was not blameless in the above controversy. It is evident, however, that both men were sadly in need of tact and diplomacy. Both men were probably ruled by self-interest, because in all the world there is not, and there never has been, any such thing as unselfishness. If these two men could have realized that it was to their selfish interests to co-operate to the fullest extent, the man-power of their respective departments would have materially increased, and it would have kept on increasing until it had reached the maximum.

Improving the Organization

Conditions and methods are changing rapidly in the industrial world, and as the pattern shop is the connecting link between the engineering department and the foundry, the appli-

cation of new methods regarding the character of the work should be discussed in conferences by the heads of these departments. In many industrial plants, where the broad principles of organization are thoroughly understood, such conferences are held two or three times each week, and oftener if the work in hand is of sufficient importance to warrant an extra session.

A large part of the money made by any concern is unconditionally due to the ability of these executives. In common with the engineering department, the pattern shop and foundry are the first points at which profits may be made, and the first place in some organizations where real ability may be shown.

Successful co-operation is largely a human question, and as most of the trouble in this world is caused by the failure of human beings to understand each other, the temperament of the individuals co-operating exercises a considerable influence on the result.

When consulting regarding the methods to be employed in handling the work, the co-operators should never lose sight of the fact that they are all working for the same company. This is a very important detail, and if strict attention is paid to it, satisfactory results are sure to follow.

In conclusion, it might be added that the departments herein mentioned are not the only places where a hearty co-operation is needed. It is needed from center to circumference in all organizations, and from the office boy to the president of the company.

Unfortunately, one does not learn very much about anything in a lifetime, but if one would practice honest, persistent co-operation, it would be realized that one can frequently "light his candle by the other fellow's flame", and if the work in the engineering department is brought to a successful and profitable conclusion, there is "glory enough for all".

Discussion

Mr. S. Griswold Flagg III:—The title of this paper is, "The Relationship of the Engineering Department to the Pattern Shop and Foundry", but most of the paper, it seems to me, calls attention to troubles in which the engineer has no part,

that come up between the various manufacturing departments of the plant. I think that sometimes we lose sight of the fact that there is quite a difference between the science and the art of the industry. The art of the industry, it seems to me, belongs to the manufacturing plant and not to the engineer. I am sure that if we were to reflect a little, we would realize that in a great measure the advance the industry has made has been largely due to the fact that the engineers have asked for what we thought were impossible things. To be sure the burden has come on the plant, but I think the advance has been largely due to the engineers.

Mr. J. W. Langston:—I am a stranger in this country and I was dumfounded to find, upon hearing this paper read, that there is a lack of co-operation between the foundrymen and pattern makers. In Australia we found that the lack of co-operation was brought about by a lack of technical education in foundrymen. It has been our experience in Australia that it is necessary to give the foundrymen a technical education. Our government compels employers to send their apprentices to school for a period of two years. The apprentices are urged to learn drawing as well as foundry practice. The boy who is taking up drawing is urged to become familiar with foundry practice so he will know the requirements of a foundry. We have been getting very good results from this plan. We take the foundryman and get him in sympathy with the drafting room.

We had a great deal of difficulty, as was outlined in Mr. McGrail's paper. In our experience we found we could get no advice worth having from the average foundry foreman in the matter of costs, simply because he did not understand drawing, but of late years owing to this compulsory education which compels every apprentice to attend school at night for two years out of his five years of apprenticeship, we are getting much better results.

Mr. Galt:—I am connected with a jobbing pattern shop. We get blueprints to figure on frequently with no specifications at all. In that way we get a lot of blame we ought not to have, and I think something ought to be done in this connection.

Mr. C. H. Gale:—I find in our concern that the engineer comes to the foundryman at times with problems that are perhaps not impossible, but impractical. I dare say the engineer is technical, while the foundryman is intensely practical, but I have found that when the matter is taken up with the engineering department in the proper spirit that they get together with the foundrymen and are always ready and willing to co-operate and where a change is suggested by the foundryman that will make the production of the casting more practical and will not interfere with the operation of the machine upon which the engineer is working. I think as a rule if the foundryman and the pattern maker will approach the engineer on the subject and show him where a slight change here and there would help in the production, without interfering with the result aimed at, the engineer will be ready and willing to co-operate.

Dr. Richard Moldenke:—I would like to say a few words to emphasize what Mr. Bean has called attention to, that the engineering and foundry departments should co-operate more than they do. I think that the foundrymen in this country have perhaps not had the co-operation of the engineers because they are generally self-made men, who began at the bottom, struggled up and have finally become foundry proprietors. They do not always realize the value of the engineer in their line of work. Now on the other side of the water, as our friend from Australia has said and as I know from personal experience, the foundrymen are trained differently and the consequence is that everything is worked out with the idea of the casting serving the purpose for which it is intended. You will find if you go into this question that those foundrymen who have brought the foundry industry to the point where it is today have been trained engineers or men who have acquired this training by study of their own. Take Mr. West, for example; he was not an engineer and yet he had a good engineering education. The engineer in the past has been pushing the foundry and he will push it still further in the future. I will just quote one instance. The railroad men are today facing the problem of using superheated steam in locomotive cylinders. These cylinders have developed a tendency

to grow out of shape because of the very high temperatures involved. The life of such a cylinder is short. The problem of the engineer is to get a hardness condition for which he is going to use the Brinnell test. We are eventually going to get cylinders which will not grow under the condition of superheated steam applied intermittently. We are going to face a great many difficulties in the near future and I have always advised foundrymen to enter the various committees on the subject and get together with engineers, sitting around the same table and discussing these problems. In regard to such a locomotive cylinder, I have been told that at present the machining costs perhaps $500 before they know whether the cylinder is fit to use or not. It is necessary to know before the machine work is put on the cylinder that it will really serve its purpose.

Mr. B. D. Fuller:—I simply want to add a little testimony as to what has been said. I am working for a large corporation and it has been interesting to follow the growth of co-operation between the shop and the engineering department. I can remember years ago we were as much separated as if we did not work for the same concern. The departments were pitted one against the other. It is vastly different today. The pattern maker apprentice must put in practically the last three months in the foundry. Only a couple of weeks ago I had occasion to make a drawing; there were no draftsmen available at the time and I sent out for one of the pattern maker's boys to come in. He made the drawing for me. In regard to the engineer, it is our custom today to have the engineer call upon the foundryman for consultation. We have meetings at least once a month to take up all questions that may arise. They are threshed out at these meetings, which I believe are doing a vast amount of good.

Mr. W. R. Bean:—Mr. Chairman, I have found in connection with what Mr. Flagg just stated, that a mighty satisfactory method of handling the pattern shop of the foundry is to give the work to a man of technical training and practical experience, let him have charge of all the mechanical equipment of the foundry where he will come into daily contact with the foundry foreman and foundry superintendent and with the

workings of the pattern shop. You should have an all-around man who would understand the molding machine equipment, the core boxes, and who would be familiar with all mechanical matters pertaining to the operation of the foundry. A title which I have used to cover such a position is that of works engineer.

MR. S. GRISWOLD FLAGG III:—I would suggest taking the foundry foreman out of the shop now and then, which will give him a broader vision. We have found it a great help to give the foundry foreman the layout, have him put his initials on the proposed blueprint and it is pretty sure to be accepted. Another thing, very often a casting is put up and there are many complicated and unnecessary parts. Call the engineer into the shop and explain it to him, and as a rule most of those difficulties are done away with. I believe that if the pattern shop foreman is given more latitude and more authority, the average shop will not be asked to do the impossible.

THE CHAIRMAN, MR. J. P. PERO:—I think, gentlemen, we make a mistake when we allow the pattern shop foreman's responsibility to cease with the finishing of the pattern. I awoke to that fact a number of years ago and in the plant with which I am connected the pattern shop foreman's responsibility does not cease when the pattern is finished. He has to follow the pattern in the foundry until the end to see that everything is right, and if it is not right he is obliged to go to the foreman and point out the fact. Now that is co-operation on a small scale, which is what we want. It spells success.

Improving the Relationship Between Employer and Employe

By J. F. KENT, Birmingham, Ala.

Whether his skin is white, black, red or yellow, man is a social animal. You can work a mule from one year's end to another and as long as you keep his stomach full he is satisfied. A man is different. On Saturday night he looks for something besides a pay envelope. You can't treat him as an animal or a machine and successfully get away with it for any length of time. He is a man and you are a man, and in that kinship lies the secret of good or bad relations.

Recognition of that kinship goes by many names, the most popular probably being "Welfare Work". No matter what you call it, however, it is the same thing; it exists in any business where men work for other men, and in any state or country. In the foundry of the American Cast Iron Pipe Co. at Birmingham, we have endeavored to give this relationship proper recognition. When I first went to Alabama, a good many years ago, I heard men with experience say that negro labor was not dependable and that the "only way to handle a nigger was to take a pick handle or some similar persuasive implement and knock him in the head about twice a week." Today three-fourths of the laborers in our shop are negroes. They are as dependable as any ordinary class of labor, and in making them so the pick handle method never has been used.

Encouraging Habits of Cleanliness

At no kind of work will a man get as dirty, perhaps, as in a big pipe foundry. Therefore, one of our first steps was the construction of a brick bath-house large enough to accommodate all of the employes. In the 12 months from Oct. 1, 1915, to Sept. 30, 1916, white employes took 25,753 baths and negro employes 166,477. When our men go to and from work they are dressed in good clothes, with white collars and polished

shoes. Few would imagine that they worked in a pipe foundry. The indirect value of these baths upon the negroes is beyond estimation. As anyone might surmise, whose olfactory nerves ever came within business distance of a thoroughbred southern negro on a warm day in June, the race is not particularly addicted to the bathing habit. The baths our men get at the shop, therefore, not only keep them clean, but communicate the infection to their families and friends, with the result that the water works company has a growing consumption among the negroes.

We installed a medical department, which, from a small beginning, has developed until today we have a thoroughly equipped operating room, consultation room for both races, dental parlors for both races, and a drug dispensary. This establishment is conducted by two doctors; one a high class surgeon and general practitioner, and the other a physician; a white trained nurse; two negro trained nurses; a dentist, and a consulting board composed of several of the leading specialists of our city. Employes pay for this service at the rate of 50 cents a month for single men and $1 a month for married men. For the married man, all members of his family are entitled to the services of the department. Needless to say, this work is very far from self-supporting. Our motive in assessing the dues is to impress upon the employe some degree of its importance and prevent abuse of the system.

Every new man now employed must stand a thorough physical examination, and if the doctors find any condition present which might endanger the health or safety of other employes the applicant is refused employment. Injured men are given first-aid treatment at the dispensary, and when seriously injured are taken to one of the city hospitals. Some years ago we had one or two cases of tuberculosis, and we constructed out-door houses for the afflicted men on top of a mountain near the plant, where their recovery has been complete.

Influence of Y. M. C. A. Activities

We have constructed a 3-story Young Men's Christian Association building. In charge of the association's activities are two trained secretaries, one who remains at the plant, and

one who spends his time visiting the homes of the employes, where he advises them about many of the phases of their daily life, especially regarding thrift, sanitation, disease prevention, cookery, education, religion and similar subjects. This work, of course, is confined to the negroes.

Under the management of the Y. M. C. A. organization is a white and negro restaurant which is open both night and day and where food is served to the employes at cost. Motion pictures are shown in the Y. M. C. A. twice weekly for both races. Other activities under the auspices of the Y. M. C. A. are a day school for negro children; employes' school for adults; Sunday school; athletics, such as base ball, foot ball, track teams, etc., and special activities such as an annual negro agricultural fair, Christmas celebrations, shop and department banquets, musical organizations, including a negro brass band and a negro chorus of over a hundred voices.

Statistics Record Appreciation

A mutual benefit association is in operation which has 1200 members out of a possible 1500, and which pays out monthly in sick, death and accident benefits an average of about $500. I am going to give you a few statistics because they afford a quick way to cover the ground. They cover a period of twelve months, as follows:

Attendance at:	White	Negro
Men's bible classes	600	1,733
Boys' bible classes	564	.....
Sunday school	3,754	547
Socials for men only	545	1,315
Moving picture shows	4,564	16,030
Educational classes	1,035	3,537
Library books used	839	40
Shower baths	25,753	166,477
Number served at restaurant (mixed)	201,604	
Number served in dining room	7,154	
Amount deposited in savings bank	$1,514.71	
Taught to read and write	13	
Attendance at athletic games, players	3,953	
Attendance at athletic games, spectators	12,030	
Medical, surgical and special cases treated at medical dispensary	21,697	

Miscellaneous Phases of Welfare Work

There are a few other phases of this welfare work which I might mention incidentally, such as a week's vacation given the shop last summer on full pay; a suggestion box plan by which every employe is given an opportunity to make sugges-

tions for the more economical or safe operation of the plant and for which cash prizes are awarded; a cash bonus of from 5 to 10 per cent on each employe's salary for the year 1916; as high or higher wages as are paid by any other employer of labor in the district; financing of homes for white employes and the construction of a model negro village with nice homes for rental to the negro employes; active and aggressive safety work in every department; and, finally, intertwining all these activities and keeping them before the employes' minds is a monthly newspaper published by and for the employes at the company's expense.

While this, of necessity, is little more than a mere catalog of what we are trying to do, I believe it should give you a more or less vivid picture of what we are using instead of the pick handle. We believe, and endeavor to make our employes realize, that their success is dependent upon ours, and ours upon theirs. As the chairman of our board of directors puts it, we strive to see "how much, not how little, wages we can pay; how easy, not how difficult, we can make our work."

We believe implicitly that a man expects, and has a right to expect, something more than that which he gets in his pay envelope, and that is what we are trying to give him.

Discussion

MR. F. M. JACKSON:—I represent the National Cast Iron Pipe Co., Birmingham, Ala. Mr. Kent's company has taken an important forward stride in the direction of safety. There is one statement he made that makes me bold to speak at this time on this question of prohibition. You gentlemen perhaps know that Alabama is one of the southern prohibition states. This question is now considered largely from an economic standpoint. Prohibition has worked out well in Alabama, and has had such an influence for the betterment of the working people that we are constrained to tell of the results everywhere we go.

Birmingham is, as you know, an iron and steel manufacturing center. The population of our city is about 190,000. There were only 26 men in the city prison, according to the last report. Think of it! Only 26 men in prison out of a population of 190,000. This is attributed largely to the elimination of the saloon.

I again say that this is an economic question, as well as a moral one, and the economist has largely superseded the moralist in advancing its interest. I believe if everybody everywhere but knew the results of the elimination of the saloon, prohibition would be universally adopted.

Mr. R. A. Bull:—I would like to offer a suggestion concerning the providing of conveniences for workmen. I know of one concern that made a very serious mistake. They provided a lot of improvements which were not appreciated by the men because of the fact that the management reminded the men constantly of what it was doing. I have seen the bad effect of that policy and I want to point out that it is a fatal mistake and will undo all the good that you try to do when you jam down the throats of the men continual reminders of what you are doing for them. Let the improvements speak for themselves; they don't need any verbal reminders. The average man in the shop does not like to be and should not be patronized.

Report of A. F. A. Advisory Committee to the United States Bureau of Standards

For the year just completed, your committee reports progress in a general way. Specifically, the following item is to be recorded: During the year, Director Stratton of the bureau of standards, requested your committee to look into the sand-blast sand situation. It seemed to him very desirable to standardize this material in view of its growing importance in the industrial world, the foundry business being but one of quite a series of industries in which sands of this character are now entering in large amounts.

Your committee, therefore, gathered a number of these sands and metal shot and made a careful study of the material. As a consequence there has been turned over to the bureau of standards a magnificent set of micrographs of the sands, their mechanical analyses, the samples themselves, etc., all of which will find valuable application in the proposed standards to be developed by the bureau.

In all, 25 samples were gathered. Of these, six were metallic and are called "angular grit" and "shot" by the manufacturers. The others are various forms of silica going under the trade names of "flint shot", "bank sand", "beach sand", "banding sand", etc.

Method of Mechanical Analysis

The method for mechanical analysis of the sands used by Mr. Saunders is given herewith. The angular grit and shot, being cast iron, were put through the sieves dry. The sands were treated by the following method to separate the grains and deflocculate any clay present. Twenty-five grams of the sand were placed into a 500 cubic centimeter, wide-mouth, glass-stoppered bottle and 300 cubic centimeters of water were added. Then there was added 2.5 cubic centimeters of ammonium hydroxide (sp. gr. 0.90) to deflocculate any clay present and

to wash and separate the grains. The glass stopper was then put in its place in the bottle, sealed with paraffin wax, and the whole rotated on a machine making about 60 revolutions per minute. The bottle being inverted at every revolution, the sand was thoroughly agitated.

After rotating for one hour the contents of the bottle were emptied upon the coarsest of a series of standard sieves arranged in the order given below:

Mesh	10	20	40	60	80	100	150	200
Opening, inches.	0.0730	0.0340	0.0153	0.0099	0.0070	0.0062	0.0038	0.0029

A jar directly below the finest or 200-mesh sieve received the residuum. A stream of water strong enough to carry the smaller particles through the larger meshes was used to wash the sand. It left the particles at the proper sieve or passed them into the jar below.

Without removing the first sieve from the nest it was washed with the stream of water until all the material capable had passed to the next sieve. The sieve was then placed on one side and the next one in order treated the same way, and so on until the contents of all the sieves had been thoroughly washed. Each sieve was then wet with alcohol, dried at 100 degrees Cent. and the sand transferred to a watch glass and weighed.

List of Sands

The micrographs are submitted in the appendix to this report.

Following is the list of the sands, shot, etc., investigated:

Name of Sand.	Producer.
No. 1, Flint Shot	United States Silica Co., Chicago.
No. 2, Crystal Silica	United States Silica Co., Chicago.
No. 3, 50 Mesh Banding Sand	United States Silica Co., Chicago.
No. 4, No. 1 Kiln Dried Sand	The Portage Silica Co., Youngstown, O.
No. 5, No. 2 Kiln Dried Sand	The Portage Silica Co., Youngstown, O.
No. 6, No. 3 Kiln Dried Sand	The Portage Silica Co., Youngstown, O.
No. 7, No. 3½ Kiln Dried Sand	The Portage Silica Co., Youngstown, O.

No. 8, No. 5½ Kiln Dried Sand..........................
....................The Portage Silica Co., Youngstown, O.

No. 9, No. 6 Dry Core Sand............................
....................The Portage Silica Co., Youngstown, O.

No. 10, No. 5 Green Core Sand..........................
....................The Portage Silica Co., Youngstown, O.

No. 11, No. 4 Green Steel Molding Sand....................
....................The Portage Silica Co., Youngstown, O.

No. 12, Washed and Dried Silica Molding Sand.............
............................Wedron Silica Co., Ottawa, Ill.

No. 13, Sand Blast Sand.........Wedron Silica Co., Ottawa, Ill.

No. 14, No. 10 Angular Grit (Iron)........................
................Pittsburgh Crushed Steel Co., Pittsburgh, Pa.

No. 15, No. 12 Angular Grit (Iron).......................
................Pittsburgh Crushed Steel Co., Pittsburgh, Pa.

No. 16, No. 14 Angular Grit (Iron) ....
................Pittsburgh Crushed Steel Co., Pittsburgh, Pa.

No. 17, No. 20 Angular Grit (Iron).......................
................Pittsburgh Crushed Steel Co., Pittsburgh, Pa.

No. 18, No. 30 Angular Grit (Iron).......................
................Pittsburgh Crushed Steel Co., Pittsburgh, Pa.

No. 19, No. 16 Shot (Iron)..............................
..............Arcade Malleable Iron Co., Worcester, Mass.

No. 20, Norton Sand ....
..............Arcade Malleable Iron Co., Worcester, Mass.

No. 21, No. 6 Sand.......................................
..............Arcade Malleable Iron Co., Worcester, Mass.

No. 22, Bank Sand..The Deane Steam Pump Works, Holyoke, Mass.

No. 23, Beach Sand.......................................
...........American Tool & Machine Co., Hyde Park, Mass.

No. 24, Beach Sand.......................................
.........Blake & Knowles Steam Pump Works, Boston, Mass.

No. 25, Bank Sand..
.........Old Colony Foundry Co., East Bridgewater, Mass.

For purposes of record, the results obtained from the mechanical analysis of the foregoing sands, etc., are given in the accompanying table.

A special report will be transmitted to the association from the U. S. bureau of standards on the work accomplished during the year in connection with the molding sand investigations. Your committee would, however, emphasize the fact that the need of this work is greater than ever at the present

time. The rush of work, scarcity of labor, transportation difficulties, etc., are accentuating the sand problem to an extent that would be bad enough with the delivery of first-class material. The quality of the shipments has, however, been distinctly under par since the rush began, with consequently deteriorated sand-heaps in the foundries. A good set of standards for the guidance of the sand merchant and foundryman alike will at least post them both on the danger line for this fundamental foundry raw material.

Your committee therefore asks that it be continued and hopes that the near future will see the question of molding sand standards, and eventually molding sand specifications, definitely formulated.

RICHARD MOLDENKE, *Chairman*
WALTER M. SAUNDERS
H. E. DILLER

TABULATED RESULTS OF SAND TESTS

Number	Per cent over 10 mesh	Per cent between 10-20	Per cent between 20-40	Per cent between 40-60	Per cent between 60-80	Per cent between 80-100	Per cent between 100-150	Per cent between 150-200	Per cent passing 200 mesh
1........	0.00	0.90	95.10	3.68	0.23	0.03	0.02	0.01	0.03
2........	0.00	0.16	65.96	26.48	3.64	0.92	2.68	0.10	0.06
3........	0.00	0.00	2.32	14.84	36.56	12.64	27.96	3.80	1.88
4........	99.20	0.08	0.16	0.10	0.06	0.04	0.06	0.04	0.26
5........	99.40	0.36	0.12	0.08	0.00	0.00	0.00	0.00	0.04
6........	91.83	7.84	0.03	0.03	0.00	0.00	0.00	0.00	0.27
7........	13.73	82.84	3.07	0.05	0.02	0.00	0.00	0.00	0.29
8........	0.00	1.13	95.70	2.74	0.05	0.05	0.03	0.04	0.26
9........	0.00	1.12	88.30	8.53	0.82	0.32	0.33	0.12	0.46
10........	0.00	0.03	11.55	27.17	23.18	9.03	23.37	2.78	2.89
11........	1.50	20.23	66.17	6.97	1.75	0.82	1.48	0.30	0.78
12........	0.00	0.08	44.58	36.14	9.85	3.24	4.75	0.70	0.66
13........	0.00	0.52	89.00	10.04	0.22	0.06	0.04	0.02	0.10
14........	99.46	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15........	50.80	49.16	0.04	0.00	0.00	0.00	0.00	0.00	0.00
16........	5.50	94.40	0.10	0.00	0.00	0.00	0.00	0.00	0.00
17........	0.80	98.66	0.54	0.00	0.00	0.00	0.00	0.00	0.00
18........	0.00	48.74	50.70	0.56	0.00	0.00	0.00	0.00	0.00
19........	0.00	97.02	2.98	0.00	0.00	0.00	0.00	0.00	0.00
20........	0.00	1.80	93.20	4.68	0.12	0.08	0.12	0.00	0.00
21........	90.00	9.60	0.40	0.00	0.00	0.00	0.00	0.00	0.00
22........	6.40	32.16	49.76	8.68	1.04	0.28	0.24	0.12	1.32
23........	19.48	45.64	31.72	1.88	0.52	0.32	0.36	0.08	0.00
24........	19.96	43.48	32.76	1.96	0.24	0.16	0.12	0.08	1.24
25........	4.96	14.84	38.88	12.68	3.80	1.88	6.72	3.96	12.28

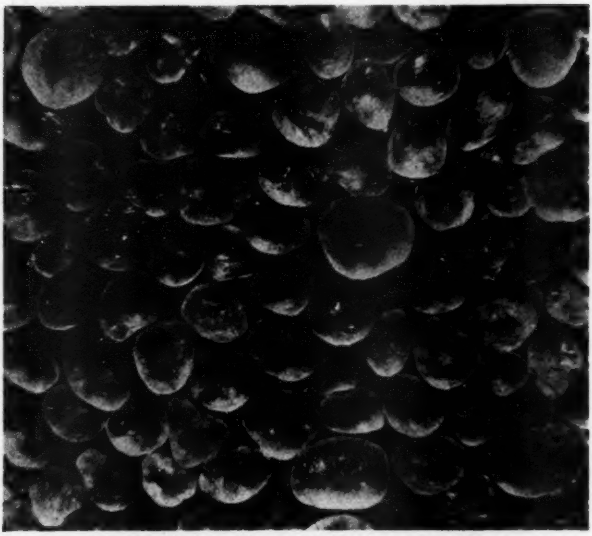


FIG. 1—FLINT SHOT MAGNIFIED 15 TIMES

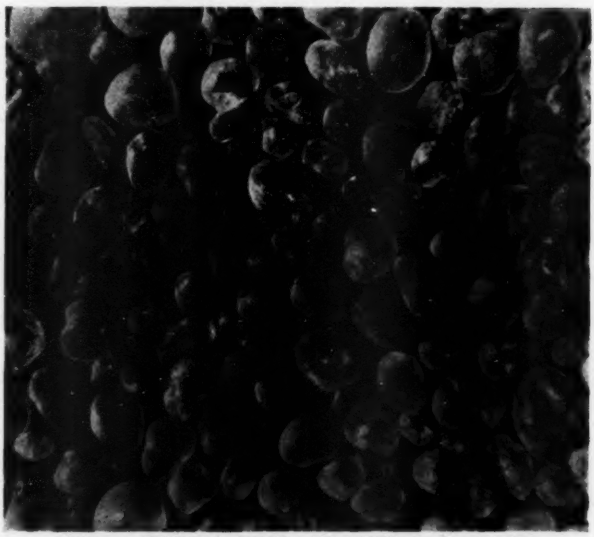


FIG. 2—CRYSTAL SILICA MAGNIFIED 15 TIMES

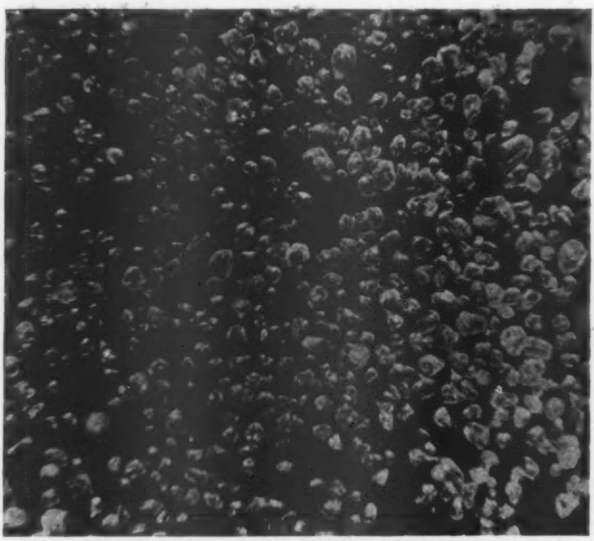


FIG. 3—FIFTY-MESH BANDING SAND MAGNIFIED 15 TIMES

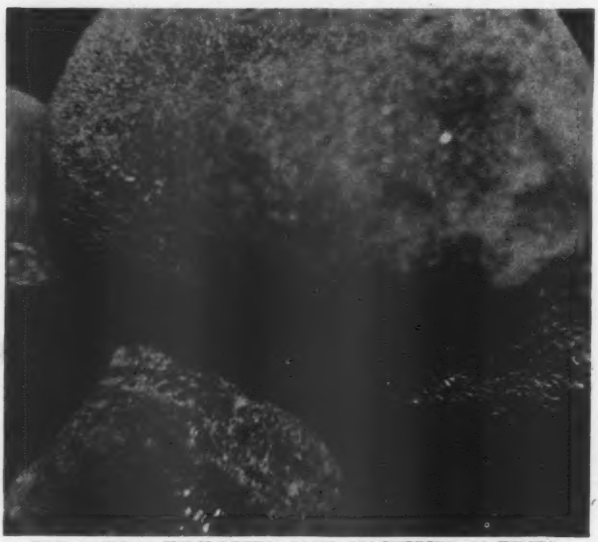


FIG. 4—NO. 1 KILN-DRIED SAND MAGNIFIED 15 TIMES

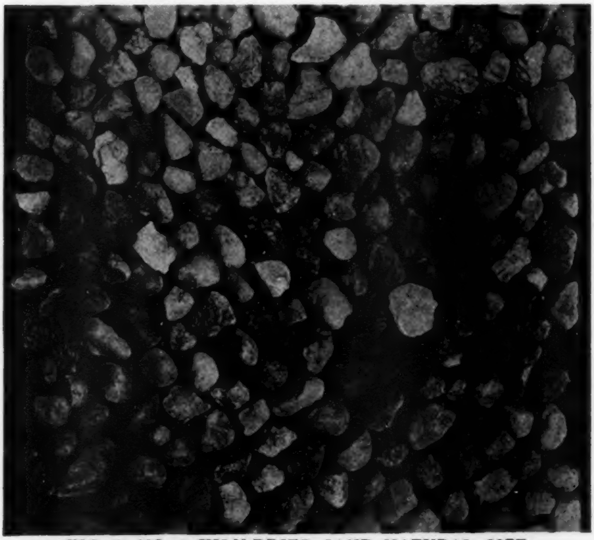


FIG. 5—NO. 1 KILN-DRIED SAND NATURAL SIZE

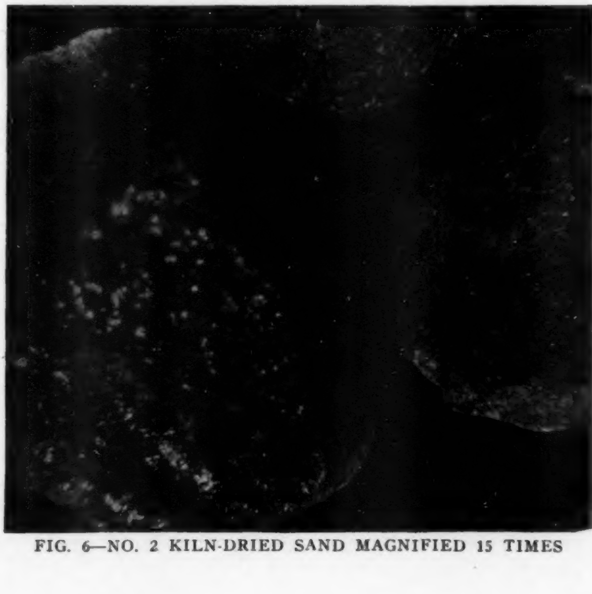


FIG. 6—NO. 2 KILN-DRIED SAND MAGNIFIED 15 TIMES

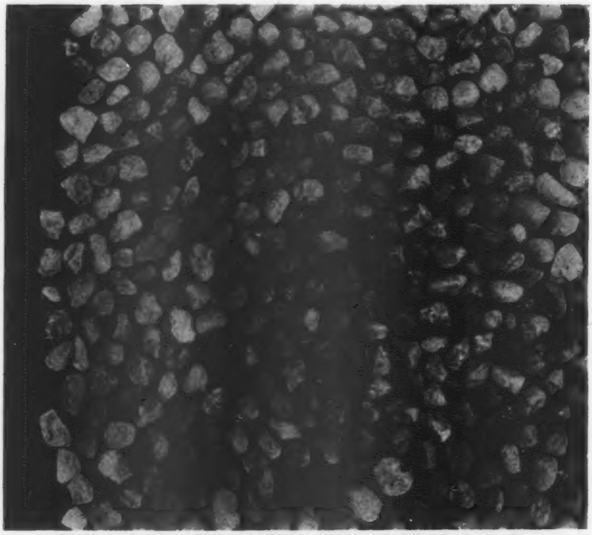


FIG. 7—NO. 2 KILN-DRIED SAND NATURAL SIZE

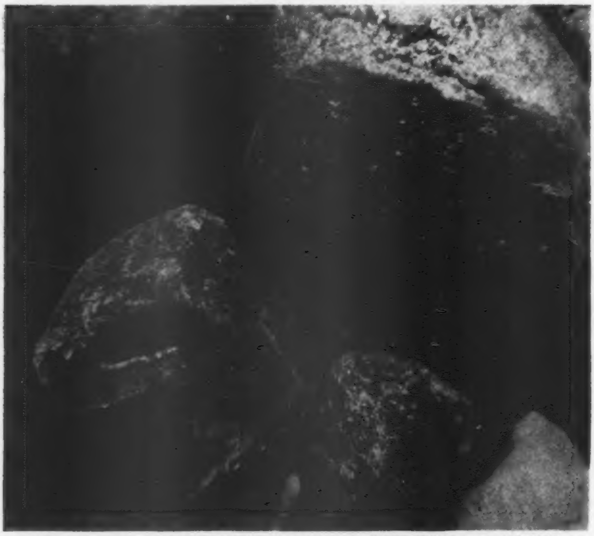


FIG. 8—NO. 3 KILN-DRIED SAND MAGNIFIED 15 TIMES

FIG. 9—NO. 3½ KILN-DRIED SAND MAGNIFIED 15 TIMES

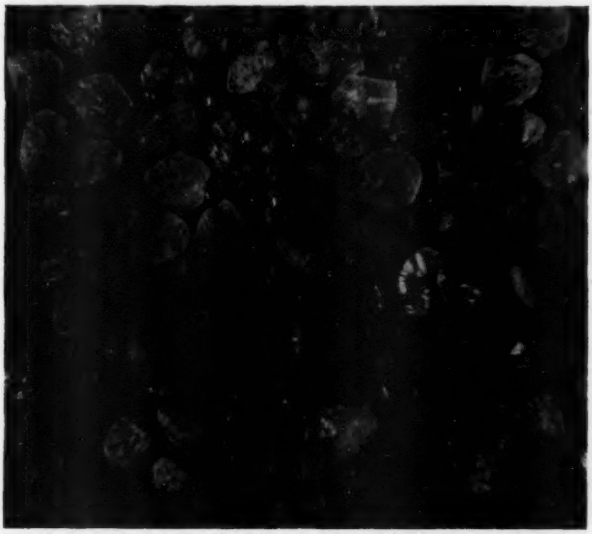


FIG. 10—NO. 5½ KILN-DRIED SAND MAGNIFIED 15 TIMES

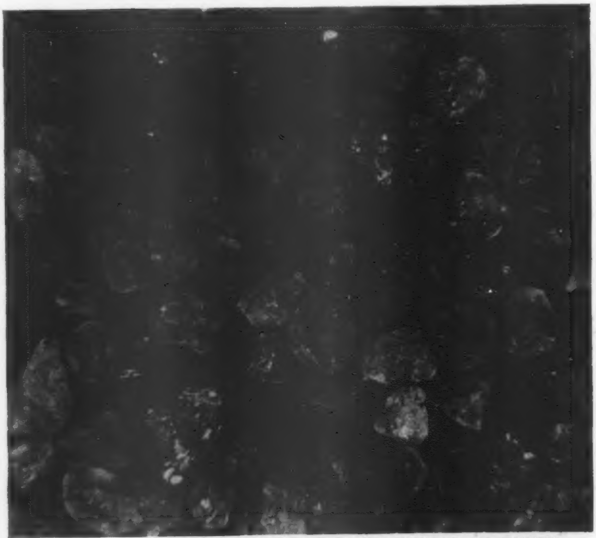


FIG. 11—NO. 6 DRY CORE SAND MAGNIFIED 15 TIMES

FIG. 12—NO. 5 GREEN CORE SAND MAGNIFIED 15 TIMES

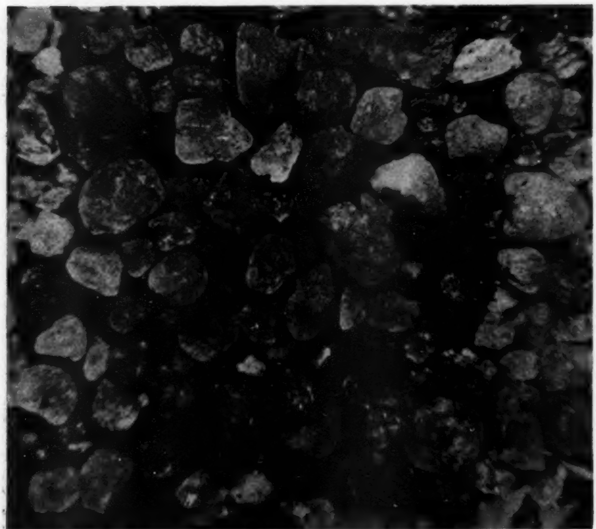


FIG. 13—NO. 4 GREEN STEEL MOLDING SAND MAGNIFIED 15 TIMES

FIG. 14—WASHED AND DRIED SILICA MOLDING SAND MAGNIFIED 15 TIMES

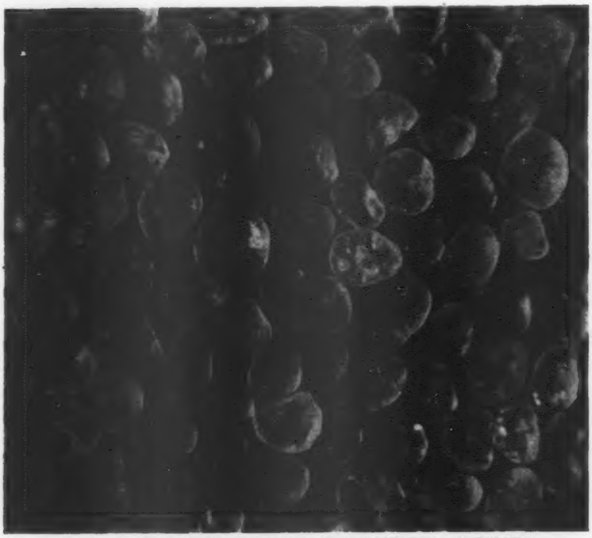


FIG. 15—SANDBLAST SAND MAGNIFIED 15 TIMES

FIG. 16—NO. 10 ANGULAR GRIT MAGNIFIED 15 TIMES

FIG. 17—NO. 12 ANGULAR GRIT MAGNIFIED 15 TIMES

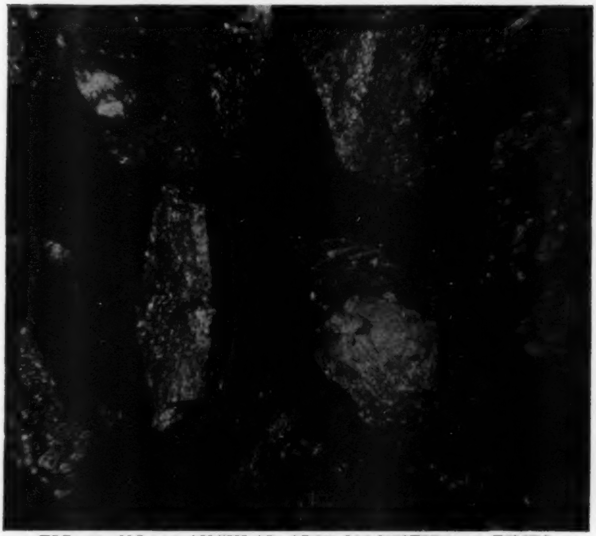


FIG. 18—NO. 14 ANGULAR GRIT MAGNIFIED 15 TIMES

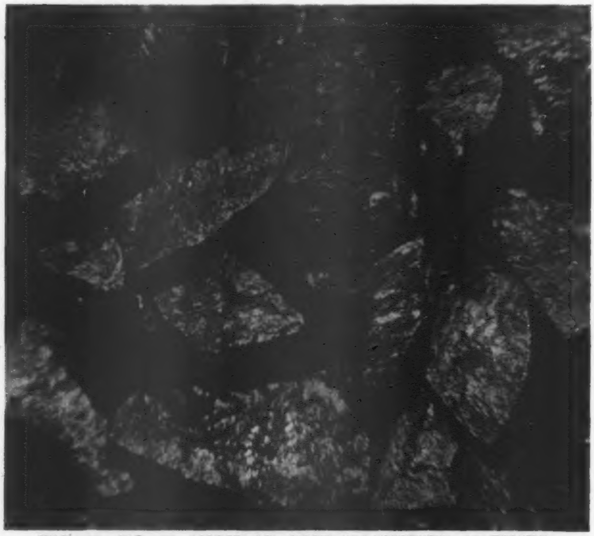


FIG. 19—NO. 20 ANGULAR GRIT MAGNIFIED 15 TIMES

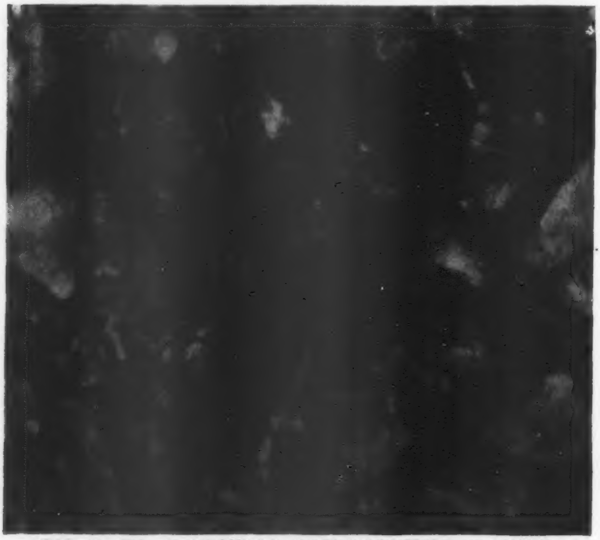


FIG. 20—NO. 30 ANGULAR GRIT MAGNIFIED 15 TIMES

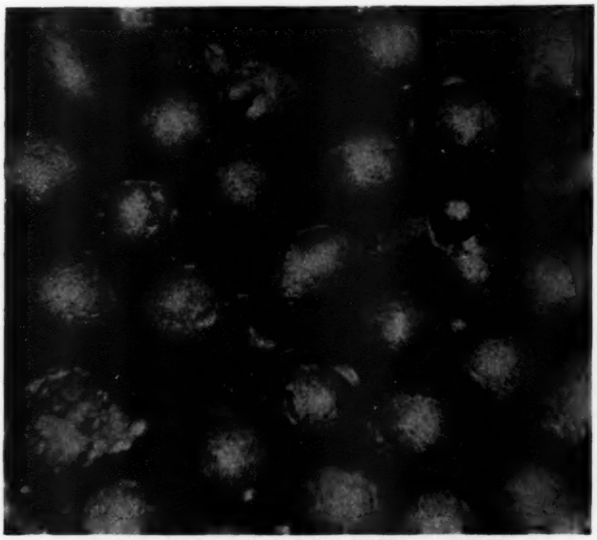


FIG. 21—NO. 16 SHOT MAGNIFIED 15 TIMES

FIG. 22—NORTON SAND MAGNIFIED 15 TIMES

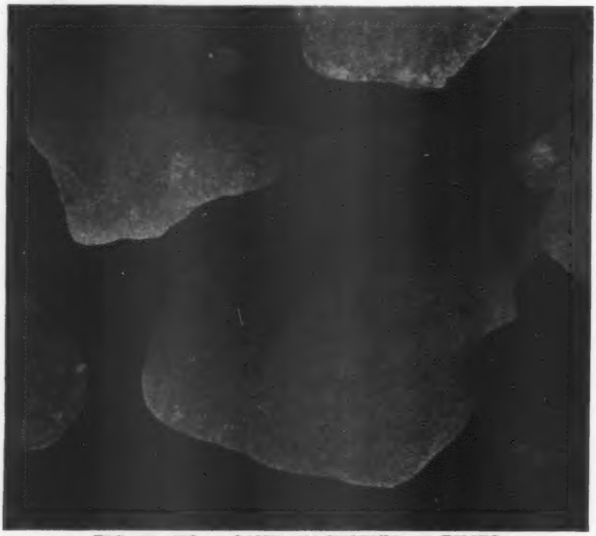


FIG. 23—NO. 6 SAND MAGNIFIED 15 TIMES

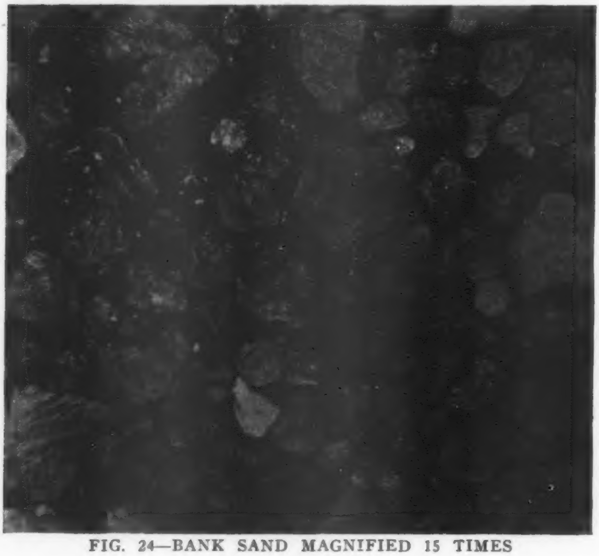


FIG. 24—BANK SAND MAGNIFIED 15 TIMES

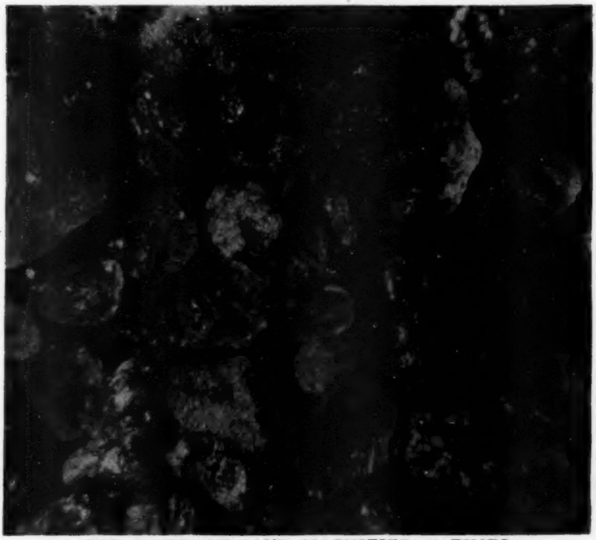


FIG. 25—BEACH SAND MAGNIFIED 15 TIMES

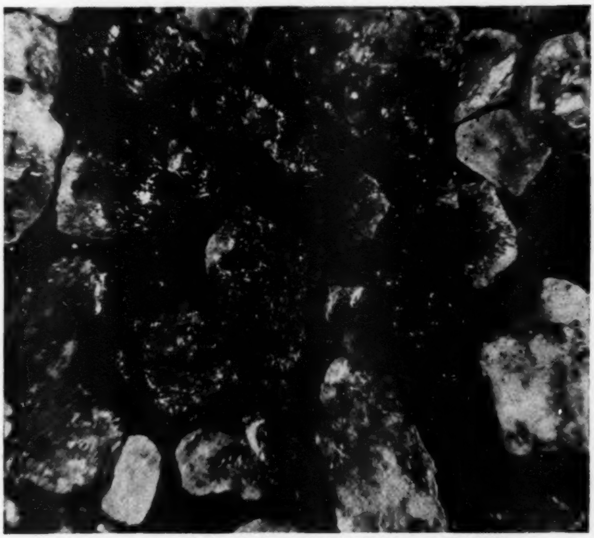


FIG. 26—BEACH SAND MAGNIFIED 15 TIMES

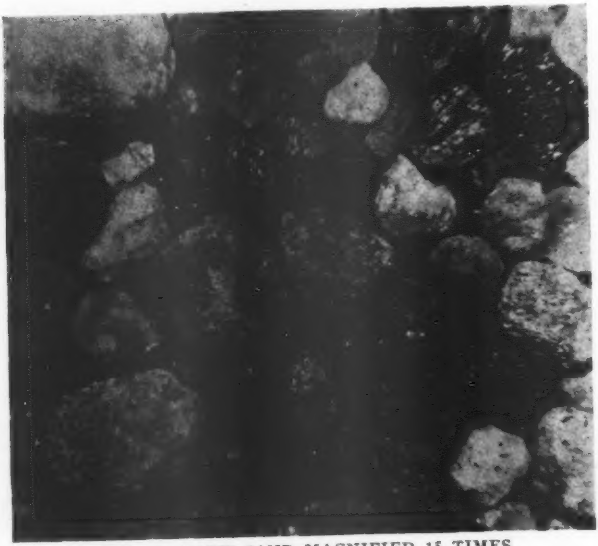


FIG. 27—BANK SAND MAGNIFIED 15 TIMES

The Foundry from the Viewpoint of the Sales Engineer

By H. R. Atwater, Cleveland

Inasmuch as the subject under discussion involves the use of molding machines, it would seem proper to state that what is said applies particularly to foundries having duplicate work.

Much has been written in reference to the lack of business methods in the foundry industry as a whole, and to the lack of appreciation of the importance of adopting progressive modern methods and labor-saving devices. Undoubtedly this criticism has been well merited, but it is also true that much has been done toward bringing the foundry up to a productive point comparing favorably with other lines of manufacture. The criticisms that have been made and the suggestions brought out in the meetings of this association, have been the means of accomplishing much good, and the industry as a whole has been greatly benefited.

It would not be an exaggeration to say that for the past five years the method of producing castings has been revolutionized. The number of pieces produced in plants per man unit has been increased in some instances 500 to 1000 per cent. This has been due principally to the installation of molding machines, means for bringing iron to the floors, sand handling devices and equipment for handling the molds from the machines.

Labor Demands Greater Share of Profits

Never before in the history of the foundry industry have the demands for greater output been so insistent as at this time. Labor is constantly demanding a larger share of the profits of the industry, and I am sure that every right-minded man wants to see the rewards of labor increased. However, labor rewards cannot be increased by simply forcing up prices on one another, in order to get this increased wage. If the

increase is to be permanent and such as can be met by the manufacturer, the production must be speeded up—where we are now getting one mold we must get at least three from no greater increase in the labor unit. To do this means better equipment and more knowledge of its use and possibilities. Those foundries that are operating entirely under hand methods are being called upon to pay a higher wage than can possibly be afforded, and in many plants the hand molder is almost an impossibility when comparing the wages demanded to the production he is willing to turn out. This condition has forced many foundrymen to install not only molding machine equipment, but methods for handling iron in pouring off the work, and in fact any equipment that will save labor and reduce the number of men required.

It is generally stated as a fact that molders do not take kindly to molding machines, or in fact to the use of any other modern device that may be placed in the foundry. In many plants this has been demonstrated to be true, although the writer knows of plants where union molders in good standing work on molding machines and turn out a production in some cases 1000 per cent greater than was done when the work was made by hand. Moreover, the wage earned is more than double any union scale in the country.

Prepare Against Curtailment of Production

In stating this fact it is not intended to open up a discussion as to which is the better method—that of trying to work molders on machines or breaking in laborers to operate them—but rather to bring up the question to the foundry industry and to ask if we are looking far enough ahead with a large enough vision to meet the requirements. Are we taking the opportunity to organize our plants and to equip them so that their production will not be cut down? This is the important thing whether we are operating with molders or so-called handy men. In these days when men are so scarce and the need of increased production is great proper means must be found to work both molders and handy men to their capacity.

It is the writer's opinion that the success or failure of modern equipment and particularly molding machines in any

given plant depends on the state of mind. Unless complete co-operation is given from the head of the plant down through the superintendent, foreman, patternmaker or others in charge, no very considerable success will be obtained from either the working of molders on the machines or the use of laborers. The thought and co-operation necessary to make a success must be such as to make a careful analysis of the cost of production on given patterns, an understanding of the proper rigging of the patterns and the kind of flasks to be used, and the price basis established on a quantity production that will largely increase the wage of the operator as well as bring a largely increased production to the plant. It is not possible to get a largely increased production unless the operators are to share in this increase.

Do Not Overestimate Returns on Equipment

I have come in contact with owners of plants where a few machines have been installed, whose sole concern seemed to be how much they could cut the molding price on all patterns that they put on machines, and the idea uppermost appeared to be that the price of the equipment should be returned to them in the first few weeks or months of operation. Naturally no large production is ever obtained in plants where this policy is pursued. Unless the men in immediate charge of foundry production first make a careful study of the possibilities of the equipment which has been installed as to the amount of work it is capable of turning out and establishes a production that is somewhere near the capacity of the equipment, they are not in position to fix a price or a wage that will insure the machines being operated at their capacity. If the equipment installed is capable of earning 100 per cent on the investment, the responsibility of realizing this must be shared in a liberal way with the men who are asked to operate it.

It would seem at this point that a word regarding the foundry foreman would be worth considering. We cannot hold a man responsible for what he does not know and it is a certainty that most of the failures to get satisfactory production from machine equipment come from ignorance both as to the possibilities of the equipment, the amount of production that should be obtained and the wages that should be paid to get the

production. There are foundries now operating in which this matter has been investigated so thoroughly and with such a broad vision that the matter of production and wages is causing them no trouble. It is not probable that these problems will bother the owners of these foundries greatly in the future, for they have builded well and they will keep well to the front, whatever demands may be made upon them. They will be in a position to properly meet all the varying changes, as they come up.

Interchange of Ideas is Beneficial

It would seem that the foundry industry as a whole could make no better investment than at every opportunity to have their foundry foremen, superintendents and those in immediate charge of production, visit modern plants, study equipment on exhibition at the different foundry shows, and encourage them to think along lines of conducting the foundries on business principles.

I am aware that the foregoing remarks cannot be applied to all foundries, owing to conditions that exist as to buildings, room for installing equipment, etc., which will not permit of operating modern equipment to the maximum production, but it is the writer's belief that if plants now operating under these handicaps are to continue in the production of castings and to meet competition, these conditions will have to be changed.

In these days it is the labor unit that must be considered, and it usually follows that men will go where the most modern equipment is furnished and where they are required to perform the least amount of labor at the highest wages. It is the writer's observation that power-operated machines are the ones most favored. Hand operated machines are not far enough removed from hard labor and the so-called skill of the molder to insure the best results. As the hand molders cannot compete with machine production even when operated by hand, neither can the hand-operated machine compare favorably with the power machine in production or saving in hard labor. It naturally follows that the hope of the foundry in the future must be in installing power equipment and in teaching laborers to successfully operate machines that will produce the largest

possible output and net the operator more money than he can possibly earn at any other work. Devices also must be furnished him that will make the labor less hard than it has been. Only in this way can the industry hold its men and turn out an equitable production.

Discussion

MR. W. R. BEAN:—I think that all of us who have had experience in the operation of molding machines will agree with what Mr. Atwater has placed before us, but his remarks lead me to mention a subject which I think is closely allied to the operation of molding machines, so closely allied that it is difficult to separate it, particularly in the malleable foundry. I refer to the handling of the metal required for pouring off the day's production. This is a very important matter in the production of castings and it is more true in the malleable foundry business than in the gray iron business, because the metal has to be taken care of in a comparatively short period of time. In order to get the most out of the molding machines, it seems to me that something will have to be done to decrease the labor required in pouring off the molds. In foundries running one heat a day the condition is perhaps a little worse than in those operating two heats a day.

In continuous foundries where small molds are poured it has seemed to me that labor effort can be reduced by transporting the metal to the floors in larger ladles, transferring it, not necessarily to hand ladles, which are ordinarily used, but to ladles of slightly larger capacity which could be carried on overhead trolleys of one kind or another. On light work of varied character in continuous foundries I think it would be advisable also to have overhead facilities for pouring. The output of the molding machine is limited by the ability of the man to carry the iron and pour the molds. I should say that at least nine out of ten men who fail to make good on molding operations in malleable foundries, fail not in producing the molds but because of the excessive labor involved in pouring the iron.

Efficiency in the Foundry

By James A. Fitzgerald, Reno, Pa.

What is efficiency; where does it start and where does it end? Efficiency is the easiest and shortest route by which we may obtain a particular desired result. Its starting point is closely allied with a good cost accounting system and its end is unmeasurable.

We are informed by statistical reports that the failures in the business world run exceedingly high and we naturally wonder why this is true. Upon investigation we find either a deplorably inefficient cost accounting system or gross inefficiency in the way the business is being conducted due either directly to faulty cost accounting or to errors of the men in authority. In the latter case, failure comes because men do not take sufficient time to consider the vital factors which control the destiny of business. I sincerely believe that there is not a man living who at some period of his life has not had the ambition to go into business for himself and has enjoyed the promise of future success. Many have succeeded after years of struggle, and if one could induce these men to honestly relate their advancement to success, they would, without doubt, mention their method of cost accounting, its efficiency or inefficiency, and its results.

Business Warnings are Unheeded

On the other hand, there are many failures of which we are uninformed because we surround ourselves with the promise of a bright future, thus preventing us from heeding the warnings sounded by the mistakes of others. For this reason, a number of manufacturers approach near to the brink of business disaster before they learn the necessity of promptly making radical changes in order to repair the damage done by inefficiency and improper cost accounting.

Efficiency in the foundry does not always imply that efficient methods shall exist only in the foundry proper. On

the contrary, efficiency must be applied in all departments. If efficient management exists all along the line, the foundry will reflect in a most desirable manner the effort that has been put forth by the men in charge.

A few years ago, whenever we had occasion to call on foundries, we generally found an ill-lighted, vile-smelling, dust-covered, dirty institution.

Today, conditions are just the reverse. Why? Because in the old days very little scientific work along foundry lines had been accomplished. The foundryman kept no real record that he could refer to and find out where or at what point in the transaction of his business he had sustained a loss. The casting business was decidedly risky from a financial standpoint or at least was considered as such. Today we have well-lighted, ventilated and heated foundries with all of the most modern and up-to-date conveniences. Moreover our shops are scrupulously clean. Why have these changes come about? One foundryman will say competition brought them, and another will say we did it in order to better our financial standing. Others will present other reasons, and each of these has a certain bearing on these changes. However, the two great factors which have brought about the transformation in the foundry are system and science. With system we keep an accurate record or records of what is being done, and with science we determine beforehand what results we may reasonably expect before we spend our money. In the foundry, as in all other lines of business, we are dealing with natural laws which have been in force ever since the beginning of time. As long as we recognize these natural laws and keep within certain well-defined limits, we may anticipate results with the assurance of success.

Report of A. F. A. Committee on Foundry Costs

At the annual meeting of your association held at Atlantic City in 1915, the suggestion was made that the members of this organization raise a fund to promote the installation of a standard cost system in the casting plants of its members. The cost committee was instructed to make an investigation and devise a plan for carrying on this work. At the meeting in Cleveland last year progress was reported, but definite action was deferred inasmuch as it was believed by the members of the committee it would be exceedingly difficult to enlist the interest of foundrymen in cost-keeping methods during a period of such great industrial activity. However, preliminary investigations proved the feasibility of the plan tentatively devised and immediately following last year's meeting it was decided by this committee to formulate a definite plan of procedure and to undertake the financing of the special cost fund to defray the expense not only of preparing the standard cost system, but to install it in the plants of the members who subscribe to this fund.

Inasmuch as the American Foundrymen's association is without adequate means to carry on such special work, it was decided to limit the benefits of the standard cost system to those members of the association, and only those, who subscribe to this fund on the basis of the number of molders and coremakers employed. This productive labor, it was believed, furnished the best index to the capacities of the plants to be interested and the cost of carrying on this work was estimated on the average number of molders and coremakers employed. It was believed that if a fund of from $8000 to $10,000 were subscribed the success of the undertaking would be assured. Estimating the possibility of an initial 100 subscribers for a

total of from $8000 to $10,000, it was decided to adopt the following schedule of charges:

Foundries employing up to 40 molders and coremakers, $50.00.

Foundries employing from 40 to 200 molders and coremakers, $1.25 for each molder and coremaker employed.

Foundries employing more than 200 molders and coremakers, $250.

It is gratifying to be able to report a total of 102 subscriptions amounting to $7,246.25, and cash payments already received from these subscribers, representing 25 per cent of their total subscriptions, aggregate $1,950.68.

Selection of Cost Expert

Two meetings of your cost committee were held during the year, principally for the purpose of considering a plan of operation and to select a cost accounting firm to carry on this work. Propositions were presented by C. E. Knoeppel & Co., New York, and Scovell, Wellington & Co., Boston. At a meeting held at Cleveland, Friday, Feb. 16, 1917, no definite decision was reached and it was concluded to extend an invitation to representatives of both of these concerns of cost accountants to explain in detail their respective propositions. On Monday, Feb. 26, a meeting was held at the William Penn hotel, Pittsburgh, which was attended by B. D. Fuller, Westinghouse Electric & Mfg. Co., Cleveland, chairman; J. Roy Tanner, Pittsburgh Valve Foundry & Construction Co., Pittsburgh; H. J. Koch, Fort Pitt Steel Casting Co., McKeesport, Pa.; C. R. Messinger, Sivyer Steel Casting Co., Milwaukee, and A. O. Backert, Cleveland. C. E. Knoeppel of the firm of C. E. Knoeppel & Co., was accompanied by W. A. McCall, a member of this firm, and C. H. Scovell represented the firm of Scovell, Wellington & Co. The representatives of both companies were afforded ample opportunity to present their propositions in detail. After considerable discussion, a letter ballot showed a majority in favor of awarding the contract to C. E. Knoeppel & Co., New York. Authority was obtained from your board of directors to enter into this contract and

C. E. Knoeppel & Co., New York, were employed for the purpose of carrying on this work.

In this connection, reference should be made to the advice and aid rendered the committee by C. H. Scovell of Scovell, Wellington & Co., in helping to devise a plan for carrying on this work. Mr. Scovell appeared before the board of directors at the Hotel La Salle, Chicago, on Jan. 28, where he explained in detail how such co-operative work was carried on and he helped map out a plan of procedure, which although not adopted, proved helpful to the committee.

The plan of procedure provides for the preparation of a standard foundry cost system that may be applied to steel, gray and malleable iron foundries and to plants making castings for the jobbing trade as well as solely for their own consumption. When the standard foundry cost system is compiled by C. E. Knoeppel & Co., it is to be submitted to your committee on foundry costs for final revision and adoption. Following the adoption of this standard cost system, it is to be printed and is to be distributed to the subscribers to this fund in the form of serially numbered pamphlets. After the subscribers have had an opportunity to study the cost system prepared a representative of C. E. Knoeppel & Co. will visit the foundries of each one of the subscribers to facilitate the introduction of this system and to outline methods whereby it may be worked into the cost system already in effect. Following the visit of the cost expert, each subscriber will receive a written report which will give in detail the methods whereby the standard foundry cost system can be adapted to the cost-keeping system in this plant. In addition, each subscriber will be permitted to continue to receive service from C. E. Knoeppel & Co. by correspondence for a period of one year, which will insure the satisfactory installation of the standard cost system and will greatly aid the cost-keeping departments of these subscribers in the adoption of these standard methods.

A Series of Investigations

Although familiar with foundry cost-keeping methods through years of practical work along this line, C. E. Knoeppel & Co. have conducted a series of investigations of representa-

tive cost systems in some of the largest plants in the United States for the purpose of obtaining information regarding the most modern methods, with a view of incorporating it in the standard foundry cost system to be adopted.

The agreement entered into with C. E. Knoeppel & Co. provides for the payment to them of 80 per cent of the total subscriptions paid into this fund, the remaining 20 per cent to be retained by your association to defray the cost of conducting the campaign for enlisting the interest of your members in this work, and to cover the cost of printing and publishing the standard cost system in pamphlet form. Twenty-five per cent of the cost of this work is to be paid to C. E. Knoeppel & Co. at the time of the adoption of the standard foundry cost system; 25 per cent after the personal visit has been made to each of the plants by an expert affiliated with this firm; 25 per cent after reports have been submitted to each one of the subscribers covering their cost methods, and the final 25 per cent payment is to be made when the work with each individual plant has been completed. Therefore, to spread out the payments into this fund as uniformly as possible, it was decided to divide each subscription into four payments. The first to be made when the subscription is received; the second after the receipt of the pamphlet containing the uniform cost system; the third after the plant has been visited by the cost expert from C. E. Knoeppel & Co., and the fourth after the receipt of the special report from the cost expert.

Due to the war conditions and the draft, the work of compiling the standard cost system has been somewhat delayed but the indulgence of the subscribers to this fund is asked since assurance is given that a thorough investigation is being made and that the resulting system will be representative of the latest and most highly improved practice. No time will be lost by the committee in its revision and its adoption in final form, and it then will be printed immediately, the pamphlets distributed and cost experts, it is believed, will be able to visit each one of the foundries of the subscribers before the end of the year.

Although the tentative total of $8000 to guarantee the undertaking of this work has not yet been subscribed, never-

theless it is believed that the success of this project has been assured and it is certain that before many months the fund will attain a total of $10,000. Your committee is more than gratified with the response to this undertaking from the large number of foundries scattered throughout the United States and Canada and it is believed that ultimately every member of your association will avail himself of this wonderful opportunity to adopt the system that will be standard throughout the plants of the members of this organization.

Inasmuch as heavy traveling expenses will be incurred in the introduction of this system outside of the industrial centers of the United States and Canada, it was decided to make an extra charge, covering traveling and other expenses, to plants located west of the Mississippi river, south of the Ohio river and outside of the province of Ontario in Canada. Efforts will be made to enlist the interest of groups of foundrymen in centers far removed from industrial communities of the United States and Canada and this will materially reduce the expenses of the cost experts and will permit its being spread over a large number of subscribers.

Some of the largest foundries in the United States, already provided with the most expert cost-keeping talent available, have become subscribers to this special fund for the purpose of improving their system, if possible. Several of these already have paid their subscriptions in full and have advised your committee that they believe in rendering every assistance possible in promoting this work although they do not feel that they will derive great benefits therefrom, owing to the highly satisfactory, modern and complete systems which they have now in operation.

Malleable Member Appointed

As constituted last year, your committee was made up of two representatives of the gray iron interests, one converter steel foundryman, one steel foundryman operating an electric furnace and converter plant and the secretary of your association. It was deemed advisable to have the malleable interests represented in this committee and thereupon, with the consent of your president, your chairman appointed C. H. Gale of the

malleable department of the Pressed Steel Car Co., McKees Rocks, Pa., to serve on this committee.

A complete list of subscribers to this fund on Sept. 1, 1917, follows:

Albany Foundry Co., Albany, N. Y.
Atlantic Radiator Co., Huntington, Pa.
Atlas Foundry Co., Detroit, Mich.

Beatty Bros., Ltd., Fergus, Ont., Canada.
Bessemer Foundry Co., Grove City, Pa.
Birmingham Iron Foundry, Derby, Conn.

Cadillac Machine Co., Cadillac, Mich.
Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich.
Canada Machinery Corp., Galt, Ont., Canada.
Carr, Stuart R., & Co., Baltimore, Md.
Central Foundry Co., New York.
Central Oil & Gas Stove Co., Gardner, Mass.
Chicago Steel Foundry Co., Chicago.
Clearfield Machine Shops, Clearfield, Pa.
Clyde Iron Works, Duluth, Minn.
Cox, Abram, Stove Co., Philadelphia.
Cyclops Foundry Co., Pittsburgh.

Darling Pump & Mfg. Co., Ltd., Williamsport, Pa.
Dayton Castings Co., Dayton, O.
Deming Co., Salem, O.
Dennison Foundry & Machine Co., Dennison, O.
Dewey Bros, Inc., Goldsboro, N. C.
Dexter Folder Co., Pearl River, N. Y.
Diamond Iron Works, Minneapolis, Minn.
Dodge Mfg. Co., Ltd., Toronto, Ont., Canada.
Domestic Engine & Pump Co., Shippensburg, Pa.
Douglas, W. & B., Middletown, Conn.
Driver-Harris Wire Co., Harrison, N. J.
Duquesne Steel Foundry Co., Pittsburgh.

Enterprise Foundry Co., Auburn, N. Y.

Fairmont Mining Machinery Co., Fairmont, W. Va.
Farquhar, A. B., Ltd., York, Pa.
Farrell-Cheek Steel Foundry Co., Sandusky, O.
Fate, J. D., Co., Plymouth, O.
Foster-Armstrong Co., East Rochester, N. Y.
Fort Pitt Steel Casting Co., McKeesport, Pa.
Frankling Machine Co., Providence, R. I.

Galt Malleable Iron Co., Ltd., Galt, Ont., Canada.
Galt Stove & Furnace Co., Ltd., Galt, Ont., Canada.
Girard Iron Works, Philadelphia.
Grey Iron Casting Co., Mt. Joy, Pa.
Griswold Mfg. Co., Erie, Pa.

Harrison Safety Boiler Works, Philadelphia.
Holland Furnace Co., Holland, Mich.
Holt Mfg. Co., Stockton, Cal.
Hunter, James, Machine Co., North Adams, Mass.

Indiana Foundry Co., Indiana, Pa.

Jencks Machine Co., Ltd., St. Catherines, Ont., Canada.
Joliette Steel Co., Ltd., Montreal, Que., Canada.
Joubert & Goslin Machine & Foundry Co., Birmingham, Ala.

La Compagnie Desjardins, Ltd., St. Andre de Kamouraska, Que., Canada.
Lake Erie Foundry Co., Buffalo, N. Y.
Lake Shore Engine Works, Marquette, Mich.
Lane Mfg. Co., Montpelier, Vt.
Lansing Foundry Co., Lansing, Mich.
Lawton, C. A., Co., De Pere, Wis.
Lincoln Iron Works, Rutland, Vt.
Locomotive Finished Material Co., Atchison, Kans.
Lombard Iron Works & Supply Co., Augusta, Ga.
Lunkenheimer Co., Cincinnati.

McAvity, T., & Sons, Ltd., St. John, N. B., Canada.
Mac Kinnon Boiler & Machine Co., Bay City, Mich.
Michigan Steel Castings Co., Detroit.
Milford Iron Co., Milford, Mass.
Milwaukee Steel Foundry Co., Milwaukee, Wis.
Minneapolis Steel & Machinery Co., Minneapolis, Minn.
Monarch Foundry Co., Detroit.
Muncie Foundry & Machine Co., Muncie, Ind.

Nordberg Mfg. Co., Milwaukee, Wis.
Novo Engine Co., Lansing, Mich.

Pelton Steel Co., Milwaukee, Wis.
Phoenix Iron Co., Meadville, Pa.
Pittsburgh Valve Foundry & Construction Co., Pittsburgh.

Read Machinery Co., York, Pa.
Ripley Foundry & Machine Co., Ripley, O.
Riverside Steel Casting Co., Newark, N. J.
Rosedale Foundry & Machine Co., Pittsburgh.
Rothe, Jos. F., Foundry Co., Green Bay, Wis.
Roots, P. H. & F. M., Co., Connersville, Ind.

Simplex Automobile Co., New Brunswick, N. J.
Simpson Foundry Co., Newark, O.
Sivyer Steel Casting Co., Milwaukee, Wis.
Smith, A. P., Mfg. Co., East Orange, N. J.
Smith's Falls Malleable Castings Co., Ltd., Smith's Falls, Ont., Canada.
Standard Malleable Iron Co., Muskegon, Mich.
Star Drilling Machine Co., Akron, O.
Superior Steel Castings Co., Benton Harbor, Mich.
Sweet & Doyle Foundry & Machine Co., Green Island, N. Y.
Swett, A. L., Iron Works, Medina, N. Y.

Taylor-Forbes Co., Ltd., Guelph, Ont., Canada.
Taylor Wilson Mfg. Co., McKees Rocks, Pa.
Taylor-Wharton Iron & Steel Co., High Bridge, N. J.
Treadwell Engineering Co., Easton, Pa.
Trout, H. G., Co., Buffalo, N. Y.

Walker Foundry Co., Erie, Pa.
Waterous Engine Works Co., Ltd., Brantford, Ont., Canada.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
West Steel Castings Co., Cleveland.
White, J. S., Co., Pawtucket, R. I.
Whiting Foundry Equipment Co., Harvey, Ill.
Williamson, J. E., Co., Bellewood, Pa.

Youngstown Sheet & Tube Co., Youngstown, O.

Respectfully submitted,

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The Sand Blast in the Foundry

By H. L. Wadsworth, Cleveland

Since the discovery of the effect of sand blasting on an American desert many years ago the art has progressed very slowly until the last few years. Originally applied to foundry work by the English, the Germans took up and developed the process very fully. In fact they carried it so far that automatic machines were built, and are now being built, to a much greater extent in Germany than in this country.

I believe, however, that the American idea of building simple machinery of great strength for continuous operation is far ahead of the German system. The Germans go to great pains to make their machinery absolutely automatic with the consequence that the machines are complicated and frail and must be operated at a rate so slow that it could not be considered in American foundries.

Better Than The Germans

A German engineer told me on my visit there with a great deal of satisfaction that of course the art of sand-blasting was discovered and developed by the Americans, but that the Germans had brought it up to its present refinement, and he was sure that they would always have first place in its manufacture. With this I cannot agree, as I am sure that there is not an American-made sand blast which is not more simple and more efficient than any of those made in Germany.

Up to within the last few years a sand-blast outfit was considered complete when a plain hose machine was installed in a wooden shed, or in an alley alongside the foundry. In recent years, however, the scarcity of labor and the increasing stringency of safety laws has greatly stimulated the development of sand-blast machinery, until at the present time, when a new foundry is being planned, the sand-blast equipment receives as much attention as the cupolas and cranes.

The sand blast has been, until recently, looked upon as a necessary evil, and consequently the proper selection of its

various parts and the installation of them has been given very little attention. This condition is gradually being changed due to the fact that most engineers in planning a new building for a foundry will call in an experienced sand-blast engineer, and in most cases follow his suggestions. The foundryman from bitter experience is beginning to realize that it pays better to put his money into good equipment to start with than to try to economize with small and incomplete outfits which must be added to in a very short time.

It has been thoroughly demonstrated that in a majority of cases sand blasting is a most efficient method of cleaning castings, especially where intricate core work is to be cleaned or a surface absolutely free from scale is desired. There are, of course, a few cases, on very simple work, where the ordinary method of tumbling is slightly cheaper, but the finish imparted by the sand-blast process is so much superior that it is usually worth the additional cost.

Two Classes of Sand Blasting

Sand blasting can be divided into two general classes, hand operating and automatic operating. Hand blasting is by far the most efficient, on all but the lightest castings, providing the conditions are proper for the operator. This is due to the fact that scale on a casting is harder in some spots than in others, and requires a longer application of the blast on the harder parts. With hand operation only, the parts that need extensive cleaning will receive it, while the soft scale can be blown off quickly.

With this fact in mind it has been the aim of sand-blast manufacturers to constantly improve their designs so that the operator is given the benefit of a strong and well-placed exhaust in connection with proper lighting of the work.

For the general run of large work which cannot be handled on the so-called automatic machines, various special sizes and types of sand-blast rooms are designed. The most common is one constructed of heavy steel throughout into which the work is conveyed on cars or trucks operating on industrial tracks or by an overhead monorail or crane. The construction of these rooms varies somewhat. In one design, the floor

is made of fine perforated steel plate through which the sand drops, while the lumps of coarse sand, wires and pieces of iron which fall from the castings, are retained on it. In some systems the sand loads automatically into the sand-blast machine from the storage hopper located underneath the floor, between the perforated plate and the pressure tank, while in others it is elevated overhead by means of chain buckets or air suction. In the former system the sand is returned to the nozzle by the air with which it is mixed under pressure through the blast lines, thus completing its cycle without the aid of any mechanical devices, while in the latter the sand is discharged from the elevator into the sand-blast machine or gravity nozzle mixer.

Rotary Table Machines

For medium-size castings weighing from 50 to say 500 pounds, which do not require handling by a crane and which are too large to be handled in tumblers or automatic machines, the rotary-table type of sand-blast room has become very popular in the past year or two, especially in the automobile and light machinery foundries. This type of room consists of a heavy revolving table frame mounted on a central shaft provided with roller bearings at top and bottom. Dividing this frame into two parts is a heavy cast iron partition varying in height from 3 to 6 feet, depending upon the work. On the frame is mounted a series of cast iron grids to carry the work. This rotary table is mounted in connection with a small steel room in which the operator works. For automobile transmission cases, cylinders, etc., a table height of about 18 inches from the floor line has been found most satisfactory as the operator does not have to bend over to do his work. It is only necessary to have a partition height of 3 feet above the table for this class of work.

For furnace and boiler castings the table is usually made flush with the floor for convenience in trucking the pieces on and off, and the partition height would be increased to 5 or 6 feet, measuring from the floor line. These tables are made in various diameters ranging from 6 to 12 feet.

This type of room really takes the place of two plain sand-blast rooms and occupies much less floor space, because

while castings are being sand-blasted by hand on the half of the table which is in the room, finished work is being removed and uncleaned work loaded on the other half. When the operator has finished the castings on which he is working, he revolves the table and partition a half turn, which takes the finished work out of the room and puts the new work before him ready to blast. It has the same effect as two plain rooms side by side, one of which is being unloaded and loaded while work is being blasted in the other.

Advantages Claimed

The rotary table room has several claims on popularity. Less floor space is required for a given tonnage. The operator can work more efficiently because the work is concentrated, the working area is reduced and is strongly lighted from all angles so that there are no shadows produced on the work. These factors result in practically continuous operation with corresponding high efficiency, low initial cost, depreciation, operation and labor.

Another Type of Room

The success of the regular type of rotary-table sand-blast room has been an incentive for further development resulting in the design of a room in which the operator stands outside in the free atmosphere and sees the work blasted through a fine brass mesh wire screen, which prevents the dust and sand from getting out. The sand-blast nozzle is operated through a slot of soft rubber in the steel casing of the room. Above this slot are located several powerful lamps to illuminate the work. The operator is not exposed in any way to the action of the blast and does not have to be protected with goggles, helmet or respirator.

The main difference between this and the ordinary type of room is that in the latter the operator is inside of the room where he can turn the castings. This is not believed to be a drawback, however, because he can work so intensively on account of the sanitary conditions that it pays to have another man at the rear of the room loading and unloading the table, or turning the work so it can be blasted on another side.

These outfits are especially valuable for boiler sections, furnace parts, gears, machine parts, etc. The actual sand-blasting space of this improved type room is so small that a smaller fan and collector can be used and still maintain a high velocity which keeps the working space practically free from dust and draws out all the fine material to the collectors.

This principle is being rapidly applied to various work in the steel, malleable and brass foundries and various shapes and sizes of plain rooms are being built, which must, of course, be designed specially for their work.

For light work there are several types of automatic machines, the most common and efficient of which is the sand-blast tumbling barrel. There are several types of these available, some of which are better adapted to certain work than others. For simple flat work such as stove plate, resistance plates, etc., the automatic rotary table is frequently used. For special work such as radiators, large plates, etc., special machines are designed.

Kinds of Abrasives

There are two kinds of abrasives used for blasting, of which the most generally used is sand which is marketed under various trade names. For practically all work a hard-grained flint sand manufactured from a quarry rock of comparatively fine mesh gives the fastest cutting. There is no rule which can be set down governing the selection of sand-blast sand, but it is my opinion that foundrymen are becoming converted to the use of fine, hard, white sand which does not break up into dust as soon as it strikes the work. It is a bad mistake to use any sand because it is cheap, for if it is cheap the chances are that it is easily produced and is of a soft nature which does not transmit the force of the air. A soft sand will also break up quickly and cause unnecessary dust in the room. The purchase of sand blast sand has been given very little thought by the majority of foundrymen, and I believe a careful study of this one point will result in a material saving.

As the most expensive single item in the operation of a sand blast is the compressed air, a few suggestions may be of value. It is a very common fault to use a compressor of just

sufficient size to operate the machinery which is first installed, with the result that it is run at full capacity all the time and many times at over-capacity. This sooner or later results in a break-down. In addition, if a foundry is not already equipped with an air compressor at the time of installing sand-blast equipment there are many uses that the air will be put to which will sooner or later have the compressor running to the limit. As a general rule I might say that to buy a compressor of twice the size called for on the estimate would not be too large in a very short time. I would recommend also the purchase of a standard and well-known make of compressor, so that repairs would be quickly available. Also if a sale were necessary to make room for larger equipment, its condition would be better and its market value higher. I make this remark because I have seen so many compressors scrapped or sold to make room for larger machines which should have been purchased in the first place. It is usually advisable to use a 2-stage compressor with a short belt drive attachment as being more efficient than the single-stage machine, although its first cost will be higher.

The choice between a motor-driven and a steam-driven compressor usually depends on local conditions. One reason for the shortage of air in most plants is that compressor catalogs list the piston displacement of the machines instead of the actual air which will be delivered by them. Different makes of the same size have the same displacement, but the efficiency varies all the way from 50 to 80 per cent. It is, therefore, important that the actual delivery of the machine be used in figuring your requirements.

In closing, I would point out that the great strides made in the development of sand-blast machinery in the past few years is conclusive proof of its efficiency. I believe that within the next few years more stringent laws will be passed requiring a high standard of working conditions not only with respect to the ventilation and lighting, but also to the proper protection of the various parts to avoid accidents. I am sure all manufacturers of sand-blast equipment are working faithfully with this end in view.

Discussion

Mr. B. D. Fuller:—In discussing this paper it may help to state the experience we have gone through in sand blasting. In the Cleveland plant of the Westinghouse company we have installed expensive equipment and the engineer who had charge of the job thought that we would go modern methods one or two better. We found it was generally specified that in the sand-blast room the air must be changed five times a minute. We concluded to double that and specified 10 times per minute. It certainly makes the room more pleasant for the operator. He can work with a great deal of freedom. In the old installation, the fresh air was brought in from the floor line and carried out overhead. We have now reversed that and the fresh air is taken in from the roof and carried out from the floor line. Naturally this keeps the dirt away from the operator. But in moving the air 10 times per minute we found we had gone a little too far. It was very difficult to keep the air pipes in repair. The joints of the exhaust pipes would cut in from two to three weeks. We applied the same method to the cleaning mills at the same time and changed the air 10 times per minute. This moved the jacks and carried them up through the pipe. I believe the most efficient service to be about half way between, say 7½ times per minute. We have slowed down to that and find we are getting efficient results.

Solution of Foundry Transportation and Conveying Problems

By Robert E. Newcomb, Holyoke, Mass.

The elimination of physical effort of the skilled mechanic or any other workman should increase his productivity. The introduction of the small molding machines of the squeezer type has generally been followed by the opposition of employes as the individual physical effort per hour is multiplied though decreased per mold. However, in some foundries the physical effort per hour has also been decreased as a result of installing other labor saving equipment.

The jar ram molding machine for the heavier side floor and crane floor work, has made a substantial reduction in the physical effort of the employe, while at the same time multiplying production.

The production of a molder or coremaker is in part limited by his physical capacity for work. It is further limited by the individual's adeptness and the patterns and core boxes supplied to him. Foundrymen are cognizant of this fact and some supply the best tools most conveniently accessible. Many foundry managers overlook the partial elimination of common labor. Notwithstanding the fact that the day laborer works for half the wages of a skilled mechanic, oftentimes his wages represent half the total labor cost of castings. This is especially true where skilled mechanics are permitted to do laborers' work.

Methods of reducing labor effort through the elimination of ramming are important and have been described many times, hence this paper is addressed to the foundryman wishing to reduce his common labor. This paper will illustrate some of the more common applications and uses of mechanical equipment used to reduce the physical effort of employes, particularly the physical effort expended in doing unskilled laborious work. In my experience, I have found that the foundry is one of the last places where the unskilled man wishes to be employed and the reason for this is that the work is usually more laborious

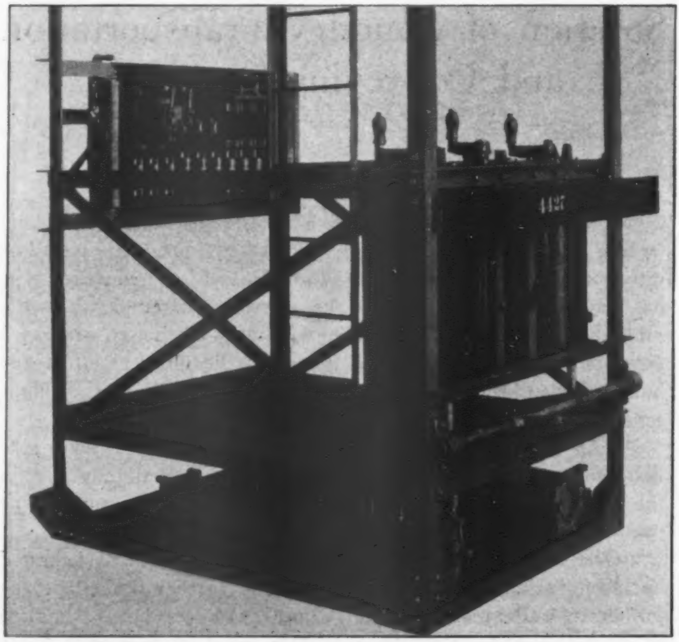


FIG. 1—CRANE CAB ILLUSTRATING DESIRABLE ARRANGEMENT OF SWITCHBOARD, CONTROLS AND RESISTANCE

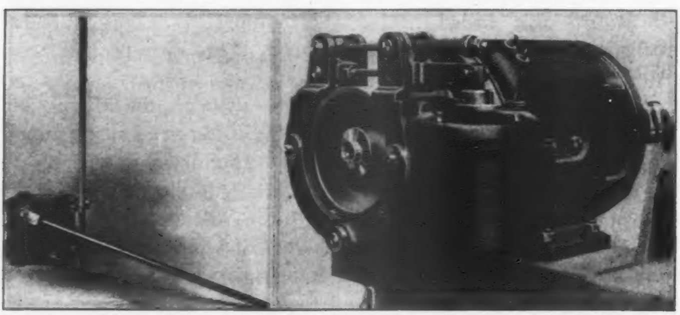


FIG. 2—LIMIT SWITCH. FIG. 3—DIRECT-CURRENT MOTOR WITH CLAM SHELL BRAKE

than many other employments and further, due to organizations limiting the development of the laborer into a skilled mechanic.

The application of such equipment as will be illustrated in the following pages will help materially to stem the tide of the ever-increasing foundry costs and at the same time make labor in the foundry more congenial.

Many foundry managers have been slow to apply mechanical equipment to reduce the cost of unskilled labor. Those who had the foresight to apply what other industries have

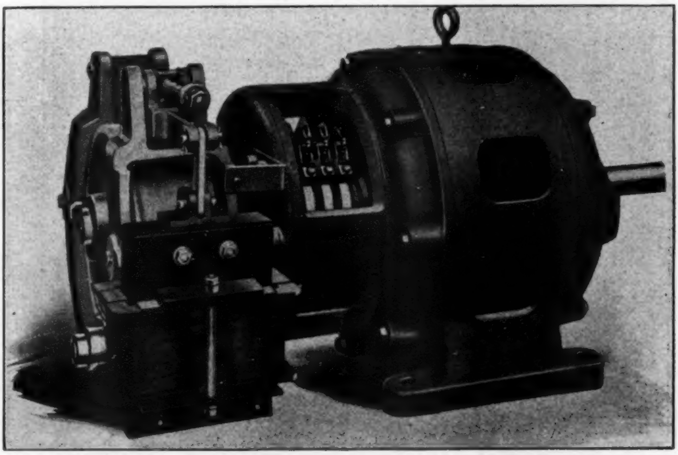


FIG. 4—ALTERNATING-CURRENT MOTOR AND CLAM SHELL BRAKE

used for some time have reaped a harvest. Foundrymen should be more familiar with the most common mechanical equipment, most important of which is the traveling crane.

The Use of Cranes in the Foundry

A crane for the foundry should have smooth regular motion and for this reason the direct-current motor crane is preferable. More recently, the alternating-current motor crane has been applied to foundry service with satisfactory results; yet, it does not give the same smooth action that is obtained from a direct-current motor crane. The alternating-current motor crane, however, has many advantages. The motor is of

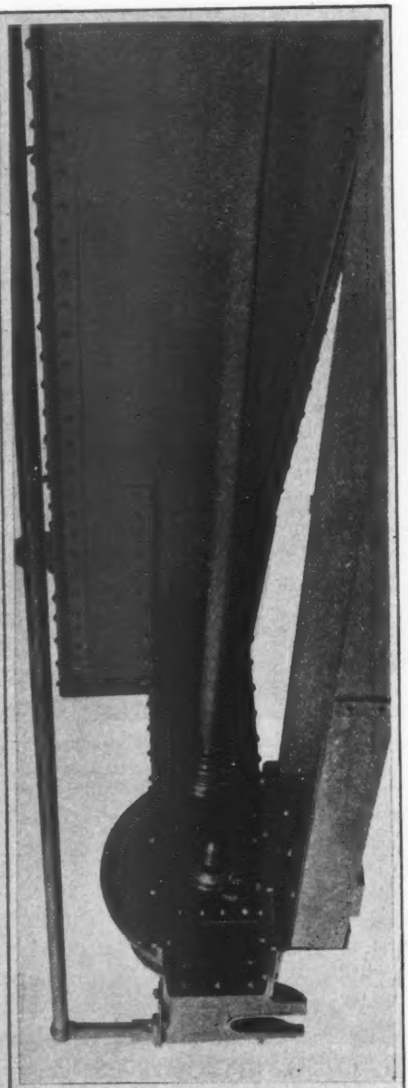


FIG. 5a—END TRUCK CONSTRUCTION SHOWING ACCESSIBLE BEARINGS
FIG. 5b—END TRUCK CONSTRUCTION SHOWING DRIVE AND ENCLOSED BEARINGS

more simple construction and has no commutators and commutator brushes to wear and give trouble.

The motors of the direct-current motor crane should be thoroughly enclosed to protect them from the dust and dirt of the foundry. In fact, it is also well to specify enclosed alternating-current motors even though it increases the cost.

Controllers Are Important

The controllers are the next most important part of the electrical equipment of the crane, hence the purchaser should consider them carefully, determine the number of points of

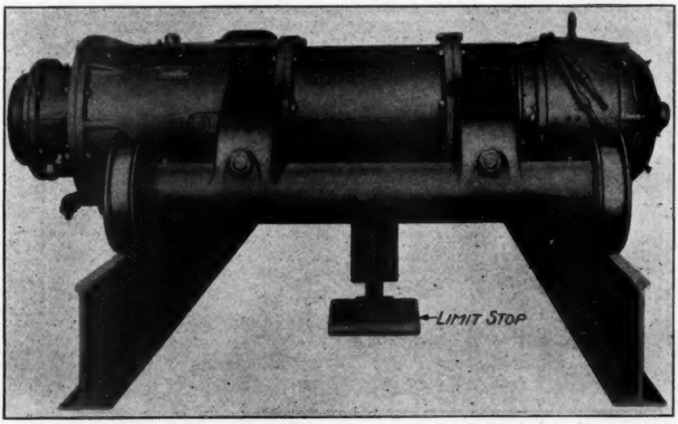


FIG. 6—BRIDGE TROLLEY HOIST SHOWING ENCLOSING OF GEARING

control of the competitive cranes and the merits of the details of the design. Controllers should be of such size and shape and so located in the cage that they will not interfere with the operation or be an obstruction to the operator when handling loads almost beneath the cage.

The switch-board is of next importance, electrically, as on it is mounted main switches, fuses, circuit breakers, etc., by which current is properly distributed to the several motor circuits and automatically as well as manually disconnected.

Fig. 1 illustrates a three-motor crane cab made by the Pawling & Harnischfeger Co., Milwaukee, complete with

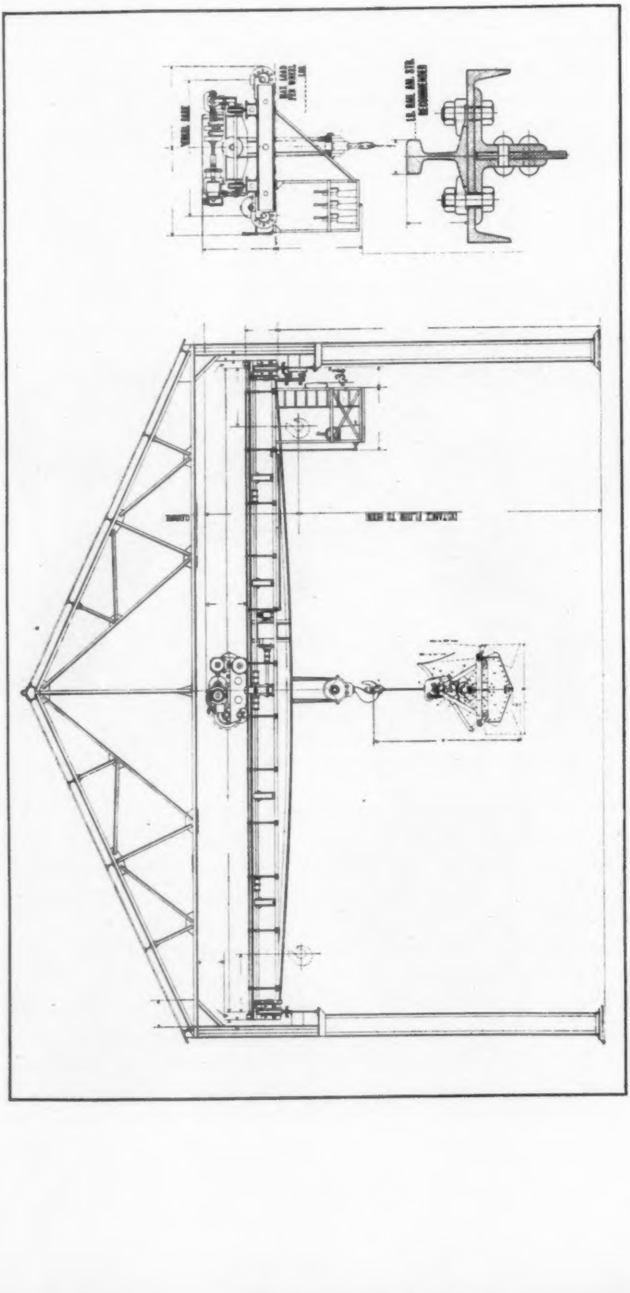


FIG. 7—CLEARANCE DIMENSIONS OF BUCKET ON CRANE

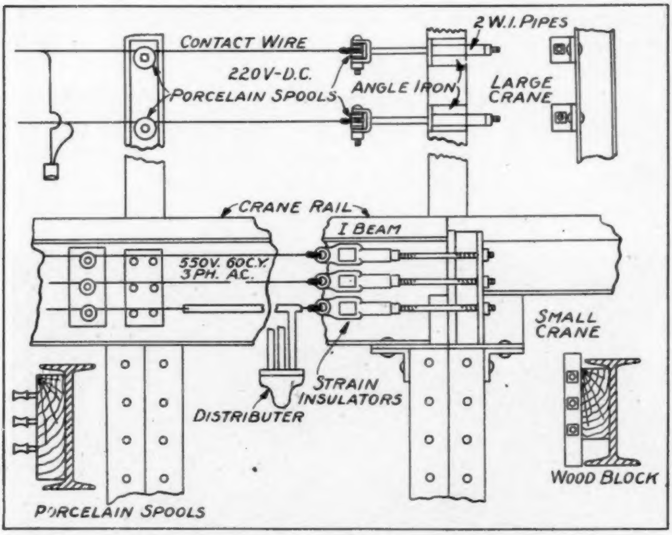


FIG. 8—METHOD OF SECURING AND SUPPORTING TROLLEY WIRES ON CRANE RUNWAY

FIG. 9 — USING BUCKET FOR CUTTING AND MIXING SAND

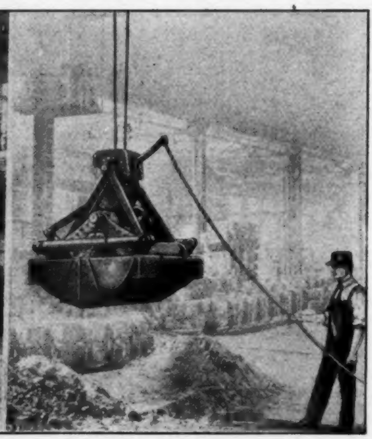


FIG. 10—GRAB BUCKET IN FOUNDRY READY TO BE TRIPPED

switch-board controller and resistance. The roomy cage, orderly arrangement of controllers and location of resistance, is well illustrated.

Fig. 2 shows a modern safety limit switch device. The rising hook moves the switch lever to prevent overtravel of the hook and consequent damage. This is a most essential feature of a hoist and its reliability should be thoroughly investigated. If through carelessness of the operator the hook

FIG. 11—THREE-QUARTER-YARD MOTOR-OPERATED BUCKET IN FOUNDRY SERVICE

should be hoisted too high, an electric limit switch automatically interrupts the current and brings the motor to a quick stop. This switch, which is enclosed in a box and operated directly from the bottom block, carries only an auxiliary current which operates a magnetic switch, mounted on the switchboard. This magnetic switch, which carries the motor current, is provided with carbon arcing contacts and a powerful magnetic blow-out. After the limit switch has been opened by the hook, the load cannot be hoisted any further. However, it can be lowered in the usual manner, whereupon the limit switch will again

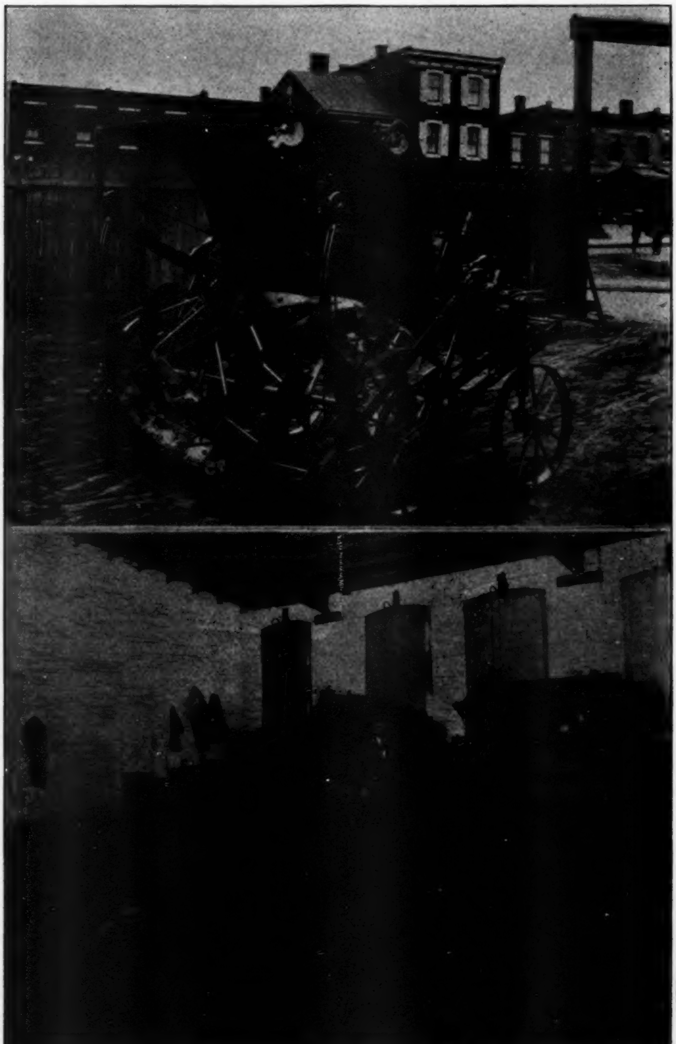


FIG. 12a—SAND CUTTING MACHINE
FIG. 12b—OPERATION OF SAND CUTTER

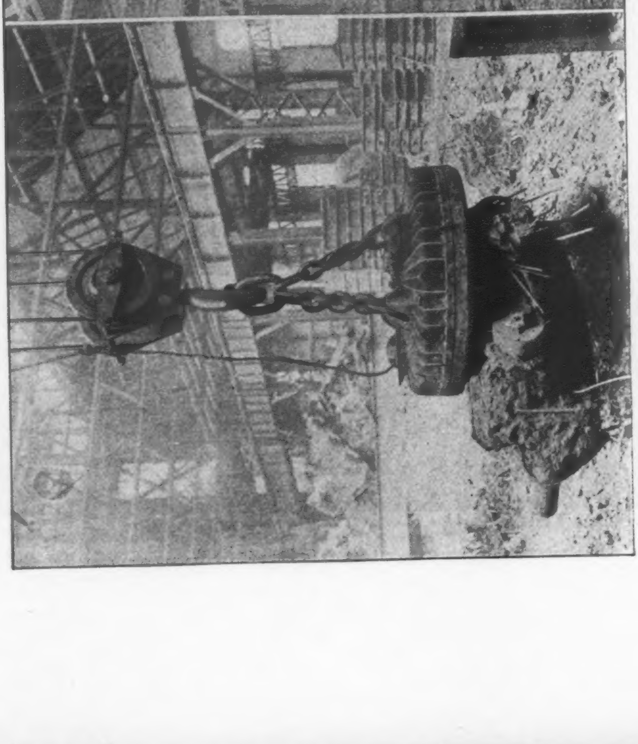


FIG. 13—HANDLING HOT CASTINGS BY MAGNET AFTER SHAKING-OUT

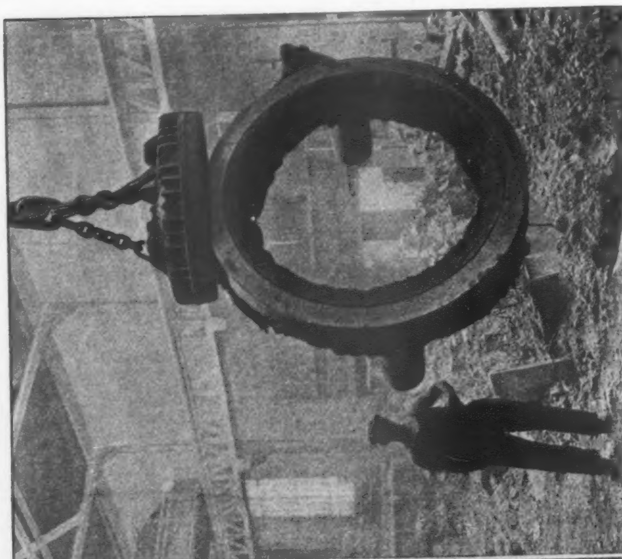


FIG. 14—CARRYING HOT CASTING TO CLEANING FLOOR

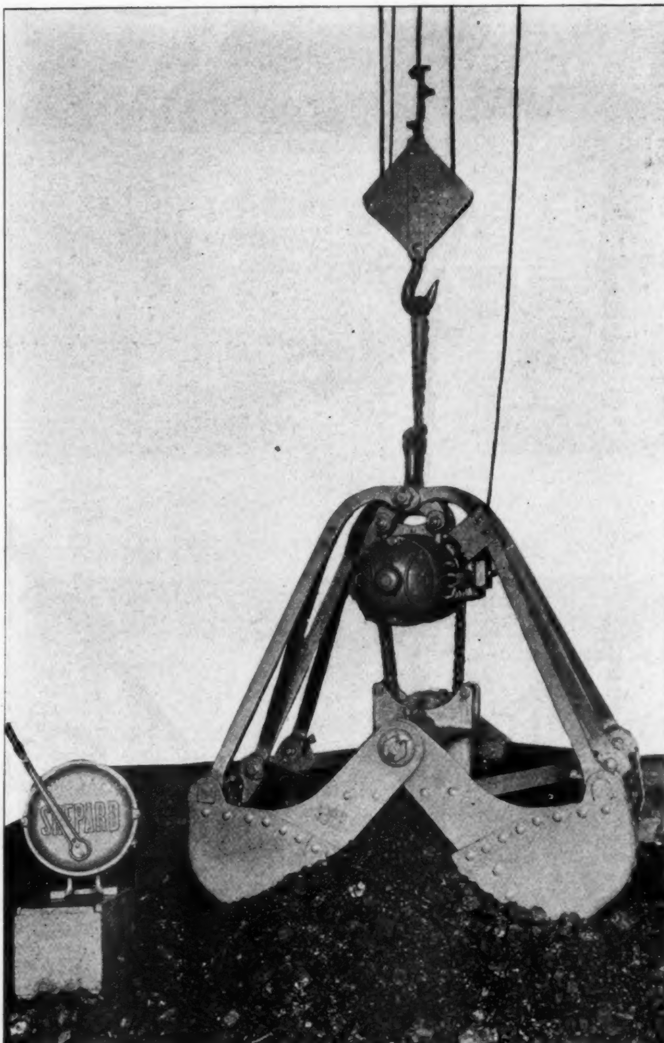


FIG. 15—MOTOR OPERATED BUCKET HANDLING COAL

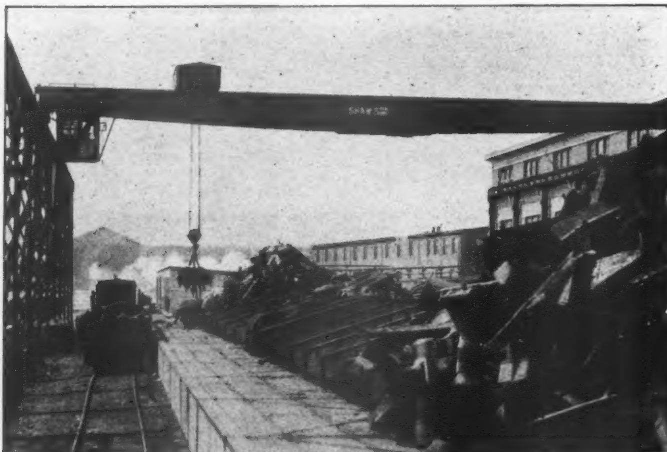


FIG. 16—UNLOADING PIG IRON WITH 62-INCH MAGNET

FIG. 17—TRAVELING YARD CRANE EQUIPPED WITH 62-INCH MAGNET

close automatically. If for any reason the limit switch is not in operative condition, the magnetic switch will immediately open. This limit switch is called a closed-current type and is said to be absolutely dependable and foolproof.

Fig. 3 illustrates a common form of electric solenoid brake which automatically goes into service the moment the power is cut off from the circuit.

The bridge girders should be of ample stiffness and strength, well secured to the bridge end trucks by riveted gussets as shown in Fig. 5*a*, and which should be equipped with bearings of the Master Car Builders' type, similar to those shown in Fig. 5*a*, permitting easy removal and replacement

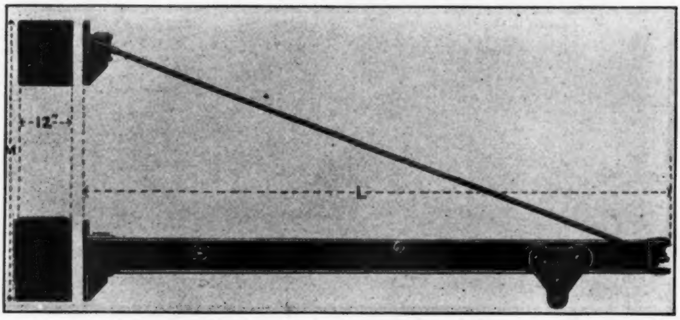


FIG. 18—DIMENSIONS OF JIB CRANES

Table of Dimensions for Fig. 18

Capacity in Tons	Dimensions in Feet and inches L	M	Size of I-Beam	Weight without Trolley
1	11'— 6"	5'—3½"	8"—18 lbs.	500 lbs.
1	13'—11"	5'—3½"	8"—18 lbs.	560 lbs.
1	16'— 5"	6'—3½"	8"—18 lbs.	620 lbs.
1	20'— 0"	7'—4½"	8"—18 lbs.	700 lbs.
2	11'— 7"	5'—3½"	8"—18 lbs.	510 lbs.
2	14'— 1"	5'—3½"	8"—18 lbs.	580 lbs.
2	16'— 7"	6'—3½"	9"—21 lbs.	700 lbs.
2	20'— 0"	7'—4½"	10"—25 lbs.	850 lbs.
3	11'— 0"	6'—3½"	9"—21 lbs.	540 lbs.
3	14'— 7"	6'—3½"	9"—21 lbs.	640 lbs.
3	16'— 8"	7'—4½"	10"—25 lbs.	780 lbs.
3	20'— 0"	7'—4½"	12"—31½ lbs.	1000 lbs.

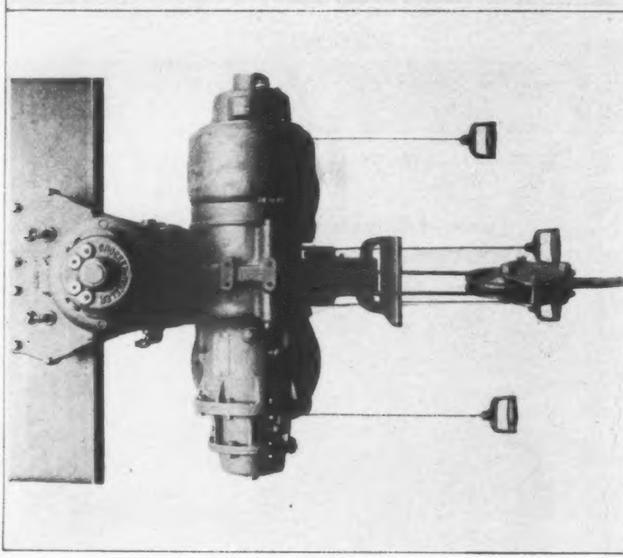


FIG. 19—ELECTRIC HOIST FOR SMALL LOADS

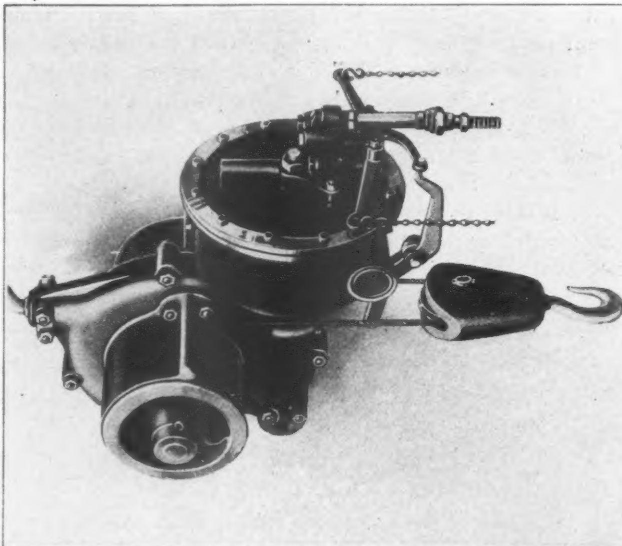


FIG. 20—AIR HOIST, 2000-POUND CAPACITY

of truck wheels and bearings. Fig. 5*b* illustrates the end truck construction employed by the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., in which the truck framing surrounds the wheels fitted to axles keyed into the hub. This construction illustrates self-oiling, self-aligning bearings set into openings in the truck frame and easily removable. This shows how to thoroughly enclose and protect from dust all bearings and gears. Bridge trucks should also be equipped with suitable bumpers to prevent damage or injury when bumping the end of the runway or other cranes, unless the bridge and frame forms a protection as shown in Fig. 5*b*. Truck wheels should

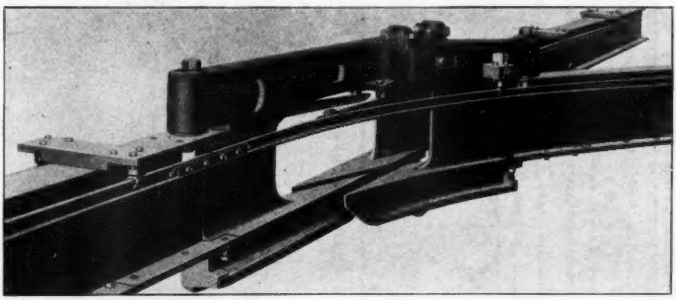


FIG. 21—FIXED-TONGUE TRACK SWITCH FOR MONORAIL TRACK

be steel castings and double flanged or cast iron with chilled treads.

The crane trolley should be of compact construction and designed to resist or compensate for tortional movement due to inequalities in the track or runway. The hoist gearing should consist of machine cut steel gears thoroughly enclosed and well supported between bearings, preferably operating in a bath of oil. These features are well exemplified in Fig. 6.

Specifications For Cranes

It is suggested that purchase specifications for traveling cranes contain the following clauses:

> All trolley gears to be of open-hearth steel castings or of better material, and all pinions of suitable forged steel. Gears to be fully enclosed. Said enclosures and crane in

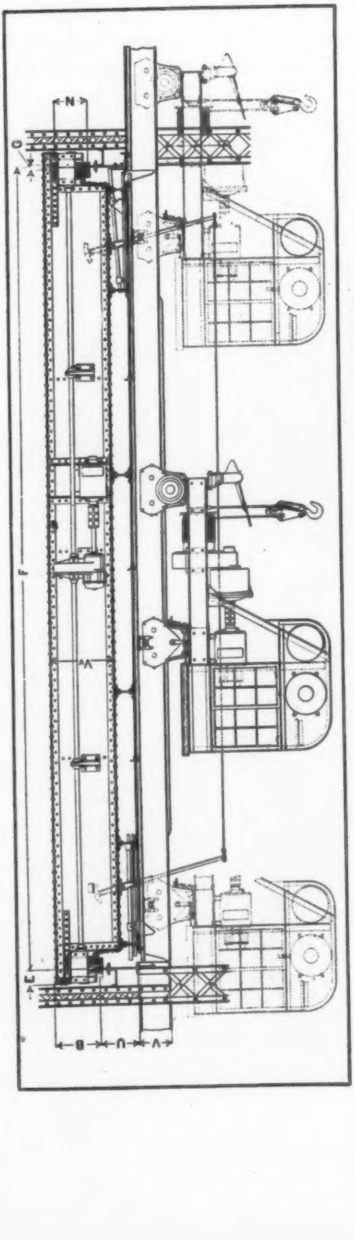


FIG. 22—MONORAIL TRANSFER BRIDGE AND HOIST

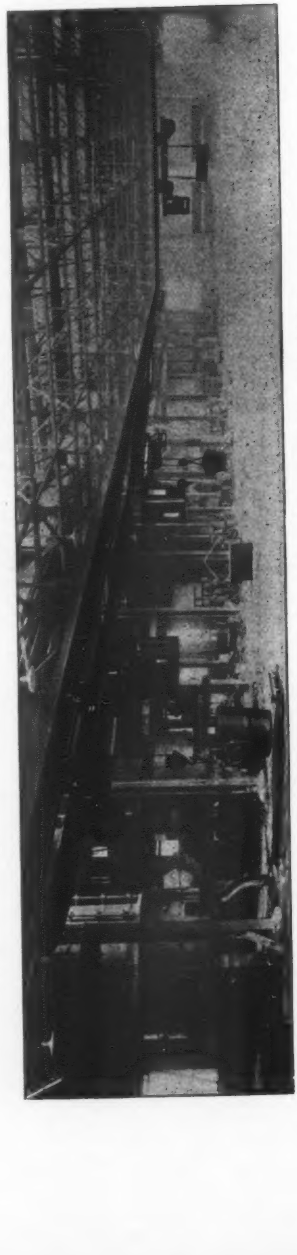


FIG. 23—MONORAIL SYSTEM IN FOUNDRY

general to be so constructed as to meet the most exacting requirements of the State industrial accident board or government authorities having jurisdiction therein, and the American Society of Mechanical Engineers code of safety standards for cranes.

Lubrication must be adequate and lubricating reservoirs and oil holes to be of such proportion as to insure a sufficient supply of lubricant reaching all parts to be lubricated. These parts should be so designed as to not require inspection or refilling more than once per day. All gears to operate in a bath of oil.

Wiring to comply with the rules and regulations of the National electric code of the National Board of Fire Underwriters and acceptable to the local electrical inspector having jurisdiction throughout the district where the crane is installed.

Crane to be guaranteed to the purchaser in design, workmanship and material. Guarantee to be good for one year from date of installation.

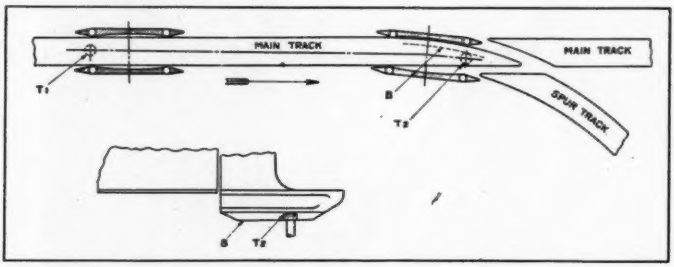


FIG. 24—STEERING THE LEADING TRUCK ON THE SPUR TRACK

The foregoing clauses are somewhat rigid and some makers will not wish to comply with them. Nevertheless, they are desirable as the manufacturers who object must acknowledge the inferiority of their equipment in these respects, hence, the selection may be made with a more complete knowledge of these essential characteristics of crane construction.

It is suggested that purchasers determine by measurements, regardless of drawings, that they have ample runway clearance, as, frequently, building construction does not accurately conform to drawings. It is unsafe to purchase a crane having less than a 6-inch side and overhead clearance. See Fig. 7 for clearance dimensions required.

The crane runway wire should be of ample size for the

FIG. 25—LOCOMOTIVE CRANE AND BUCKET UNLOADING A CAR

addition of one or more cranes; it should be of hard drawn copper wire supported on insulators, as shown in Fig. 8.

The following illustrations show some of the more unusual applications of a traveling crane. Fig. 9 illustrates a single-line grab bucket, made by the Pawling & Harnischfeger Co., suspended from a crane hook. Fig. 10 illustrates the operation of a grab bucket in a foundry, while Fig. 11 illustrates a unique motor-driven grab bucket made by the Hayward Co., New York, operating under similar conditions. These grab buckets are designed to hold from one to one and one-half cubic yards

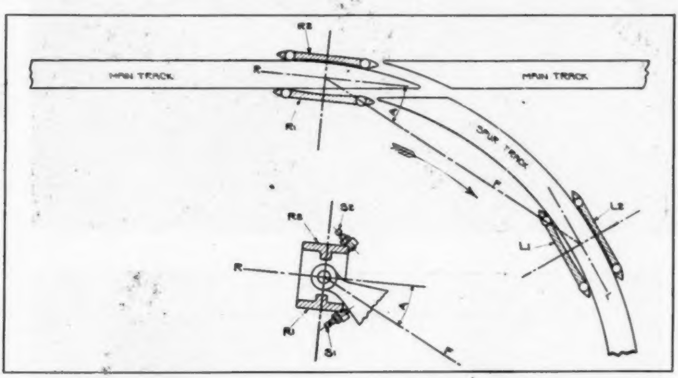


FIG. 26—STEERING THE REAR TRUCK ON THE SPUR TRACK

and may be conveniently used for transferring such materials as molding sand in conjunction with sand-mixing machines.

A foundry melting 30 and 40 tons of iron per day has 75 to 100 tons of sand distributed upon the molding floors. It is customary for the molder to cut and temper this sand. The manual cutting and tempering of sands is a prolific cause of bad castings not easily controlled. The introduction of motor-driven portable sand-mixing machines as shown in Figs. 12 *a* and *b* may be operated and conducted by a specially trained operating crew with improved results. The machine illustrated was made by the Sand Mixing Machine Co., New York.

In other foundries, belt and bucket conveyors are used to return the sand to a central sand mixing and tempering plant

FIG. 28—HANDLING PIG IRON WITH A 43-INCH MAGNET

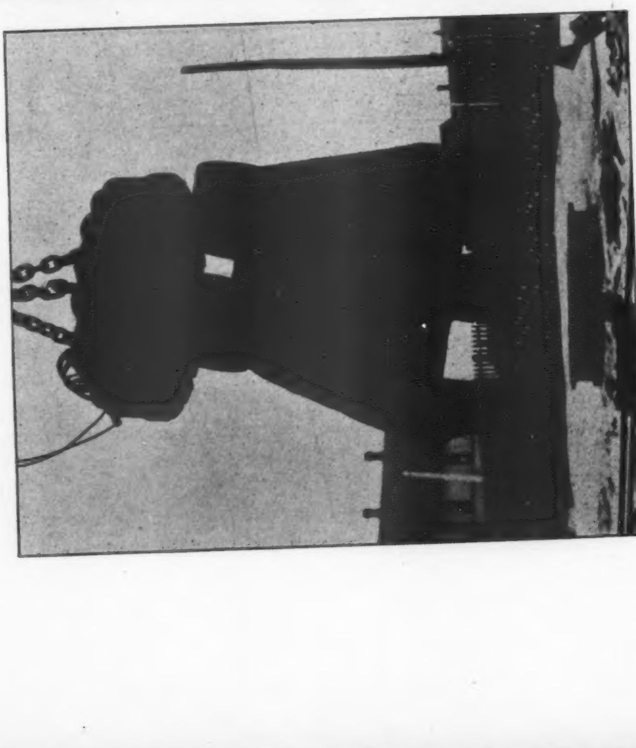


FIG. 27—A 3500-POUND CASTING HANDLED BY A MAGNET

which is, of course, first rate practice, as this quantity of sand may easily be handled to and from the molding floors at a cost not to exceed $0.01 to $0.02 per ton and within one hour's time. Such an equipment may cost from $20,000 to $25,000.

The same material may be moved to the central sand-mixing plant and returned to the molding floors with a grab

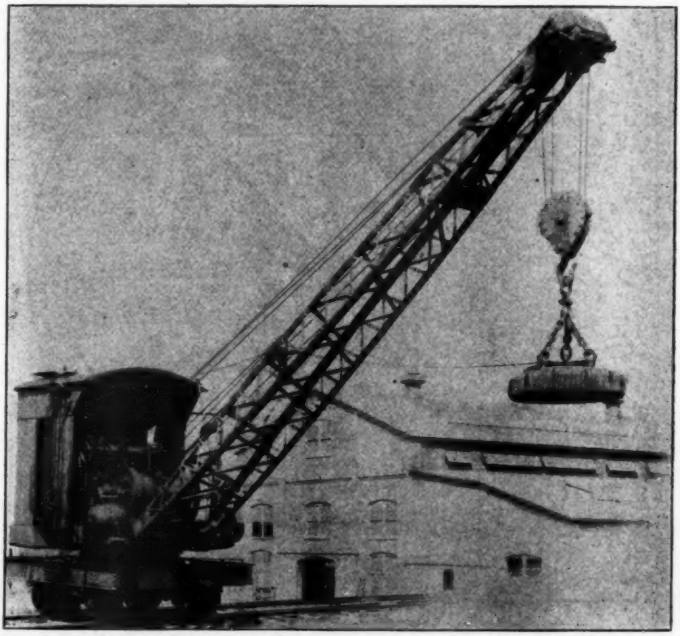


FIG. 29—LOCOMOTIVE CRANES EQUIPPED WITH MAGNETS FIND MANY USES

bucket costing less than $3000 fully equipped with accessories except crane. The material may be moved during one hour following the heat and returned one hour before the starting time the following day at a cost not over $0.025 per ton of sand.

In addition the bucket may be used throughout the day for filling large molds, for excavating pits and for unloading incoming coke, coal and sand. A detail view of the Hayward bucket

is shown in Fig. 15. This bucket is entirely controlled from the cage of the traveling crane.

The most undesirable and dirtiest part of the day's work in the foundry is dumping out castings, and for this work a magnet may be used with economical and satisfactory results

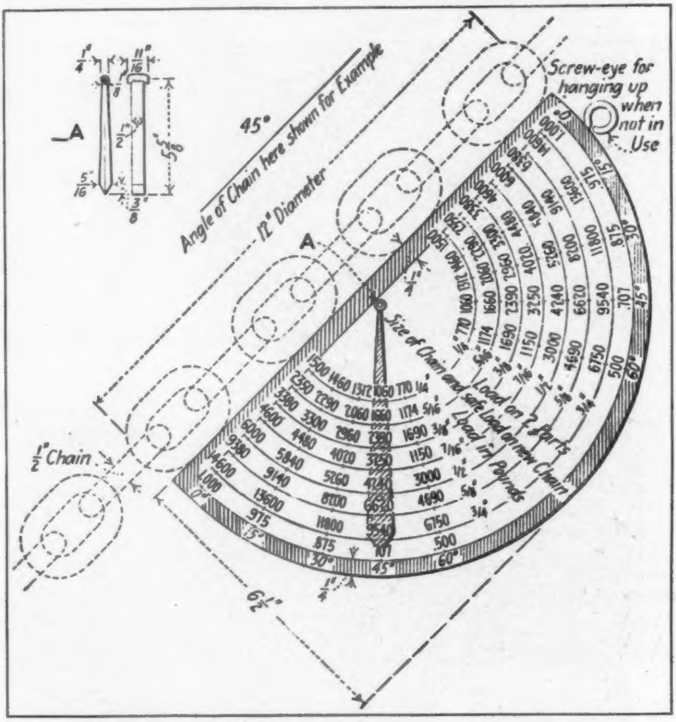


FIG. 30—SAFE-LOAD GAGE FOR CHAIN AND ROPE SLINGS

as shown in Figs. 13 and 14. Figs. 16 and 17 show traveling cranes applied to yard work; in one instance both buckets and magnets are shown, indicating the ease with which material is here handled.

Jib or bracket cranes similar in design to that shown in Fig. 18 are of great value and relieve the overhead traveling

cranes. Especially are they convenient and valuable when used in connection with the setting of cores. These cranes may be made to cover a large area, handling the work for several floors, and can be erected on any wall or post, and may be swung out of the way of any work on the floor. They may be equipped with geared triplex blocks, air or electric hoists.

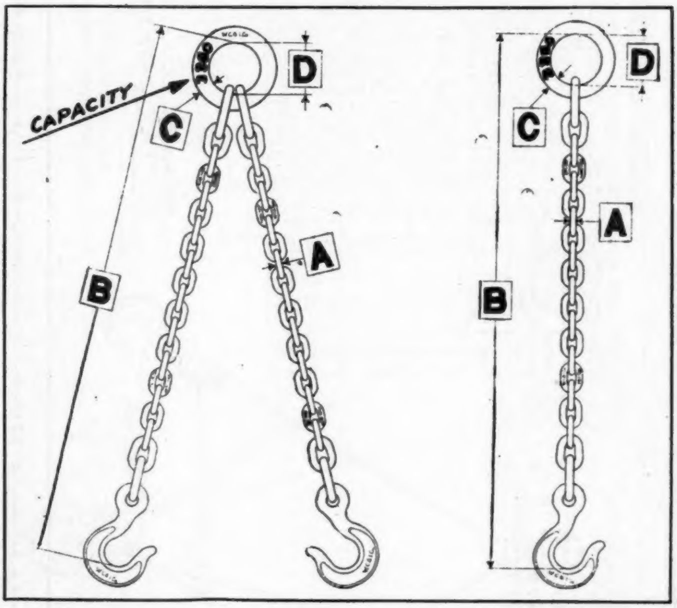
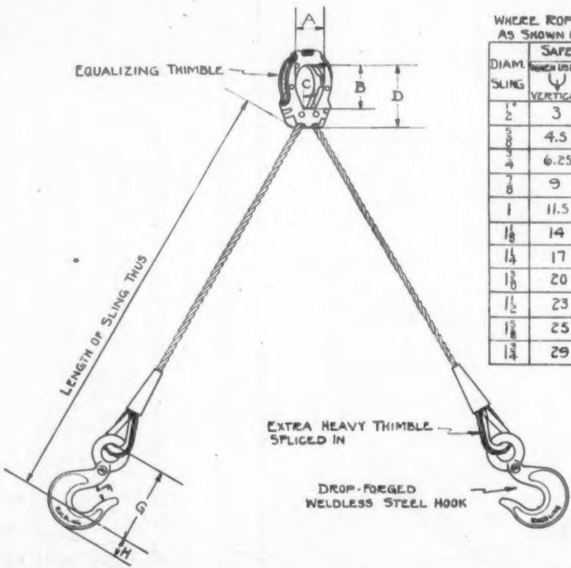


FIG. 31—METHOD OF MARKING SAFE LOADS FOR SLINGS

Fig. 19 shows an electric hoist costing two or three times as much as a representative air hoist shown in Fig. 20. Probably the air hoist is not as economical as the electric hoist in the use of power and may cost more to maintain. It, however, has the advantages of a more satisfactory and smooth movement such as is desirable for setting cores while its initial cost makes it an attractive purchase.



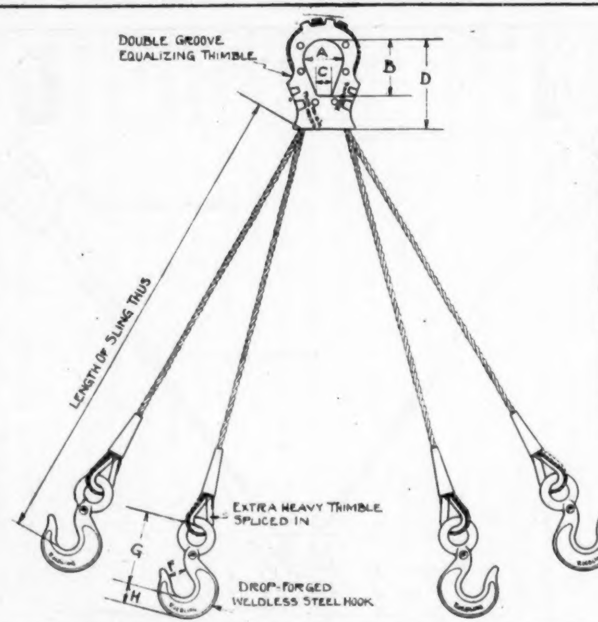
MAXIMUM SAFE LOADS, ETC.

WHERE ROPE DOES NOT COME IN CONTACT WITH THE MATERIAL HOISTED AS SHOWN IN FIG 1, PER "CS-168." SAFE LOADS IN TONS OF 2,000 LBS.

DIAM. SLING	SAFE LOADS: WHEN USED VERTICAL	SAFE LOADS: WHEN USED 60° ANGLE	HOOK: SIZE HOOK	HOOK: F	HOOK: G	HOOK: H	EQUALIZING THIMBLES SET "M": A	SET "M": B	SET "M": C	SET "M": D	SET "L": A	SET "L": B	SET "L": C	SET "L": D	SET "SP": A	SET "SP": B	SET "SP": C	SET "SP": D
$\frac{1}{2}$"	3	2.5	25	$1\frac{1}{2}$"	$5\frac{7}{16}$"	$1\frac{9}{16}$"	$3\frac{7}{8}$"	$5\frac{1}{2}$"	$1\frac{1}{4}$"	$7\frac{3}{4}$"								
$\frac{5}{8}$	4.5	4	30	$1\frac{5}{8}$	$6\frac{5}{16}$	$1\frac{3}{4}$	$3\frac{7}{8}$	$5\frac{3}{4}$	$1\frac{3}{8}$	$8\frac{3}{8}$								
$\frac{3}{4}$	6.25	5.5	40	$1\frac{7}{8}$	$7\frac{1}{2}$	2	$3\frac{7}{8}$	$5\frac{3}{4}$	$1\frac{3}{8}$	$8\frac{3}{8}$					8	12	$1\frac{7}{8}$	15
$\frac{7}{8}$	9	8	50	$2\frac{1}{8}$	$8\frac{7}{16}$	$2\frac{5}{16}$	$5\frac{1}{4}$	8	$1\frac{1}{4}$	$10\frac{1}{4}$	$6\frac{5}{8}$	$10\frac{1}{4}$	$1\frac{15}{16}$	13	8	12	$1\frac{7}{8}$	15
1	11.5	10	65	$2\frac{7}{16}$	$9\frac{1}{2}$	$2\frac{9}{16}$	$5\frac{1}{4}$	8	$1\frac{1}{4}$	$10\frac{1}{4}$	$6\frac{5}{8}$	$10\frac{1}{4}$	$1\frac{15}{16}$	13	$8\frac{1}{2}$	13	$2\frac{1}{16}$	16
$1\frac{1}{8}$	14	12	75	$2\frac{9}{16}$	$10\frac{5}{16}$	$2\frac{3}{4}$	$5\frac{1}{4}$	$7\frac{3}{4}$	$1\frac{1}{2}$	$10\frac{1}{2}$	7	$10\frac{5}{8}$	2	$13\frac{5}{8}$	$8\frac{1}{2}$	13	$2\frac{1}{16}$	16
$1\frac{1}{4}$	17	14.5	90	3	$11\frac{11}{16}$	3	$5\frac{1}{4}$	$7\frac{3}{4}$	$1\frac{1}{2}$	$10\frac{1}{2}$	7	$10\frac{5}{8}$	2	$13\frac{5}{8}$	$8\frac{1}{2}$	13	$2\frac{1}{8}$	$16\frac{1}{4}$
$1\frac{3}{8}$	20	17	110	$3\frac{5}{16}$	$12\frac{7}{16}$	$3\frac{1}{8}$	6	$9\frac{3}{4}$	$1\frac{3}{4}$	13	$8\frac{1}{2}$	13	$2\frac{1}{8}$	$16\frac{1}{4}$				
$1\frac{1}{2}$	23	20	125	$3\frac{3}{4}$	$13\frac{5}{8}$	$3\frac{1}{2}$	6	$9\frac{3}{4}$	$1\frac{3}{4}$	13	$8\frac{1}{2}$	13	$2\frac{1}{8}$	$16\frac{1}{4}$				
$1\frac{5}{8}$	25	22	150	$4\frac{1}{2}$	$15\frac{1}{2}$	4	9	14	2	$17\frac{3}{4}$								
$1\frac{3}{4}$	29	25	175	5	18	$4\frac{3}{4}$	$9\frac{3}{4}$	15	$2\frac{1}{2}$	$19\frac{1}{2}$								

EQUALIZING BRIDLE SLINGS WITH HOOKS
"BLUE CENTER STEEL" ROPE

FIG. 32—TABLE OF SAFE LOADS OF BRIDLE SLINGS ISSUED BY JOHN A. ROEBLING'S SONS CO.

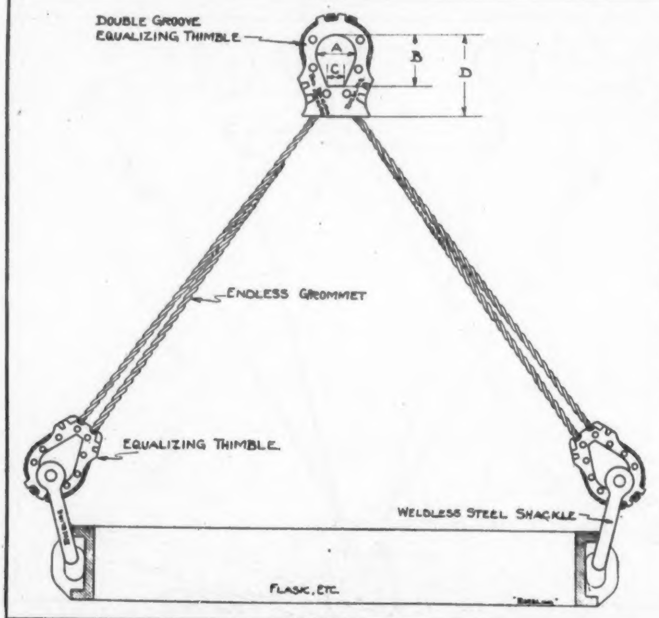


MAXIMUM SAFE LOADS
IN TONS OF 2,000 LBS.
WHERE ROPE DOES NOT COME IN CONTACT WITH THE MATERIAL HOISTED, SIMILAR TO SLING FIG 1, PER "CS-168."

DIAM. SLING	SAFE LOADS IN TONS WHEN USED 60° ANGLE	SAFE LOADS IN TONS WHEN USED 45° ANGLE	THIMBLE A	THIMBLE B	THIMBLE C	THIMBLE D	HOOK SIZE HOOK	HOOK F	HOOK G	HOOK H
½"	5	4.25	5¼"	7¼"	2"	11¼"	25	1½"	5 7/16"	1 7/16"
⅝	8	6.5	5¼	7½	1 15/16	11⅞	30	1⅝	6 5/16	1¾
¾	11	9	5¼	7½	1 15/16	11⅞	40	1⅞	7½	2
⅞	16	12.5	6½	8¾	2⅜	14¼	50	2⅛	8 7/16	2 5/16
1	20	16	6½	8¾	2⅜	14¼	65	2 7/16	9½	2 9/16
1⅛	24	20	8	11¼	2⅝	17¾	75	2 9/16	10 5/16	2¾
1¼	29	24	8	11¼	2⅝	17¾	90	3	11 11/16	3
1⅜	34	28	9	12	3½	19	110	3 5/16	12 7/16	3¼
1½	40	32	9	12	3½	19	125	3¾	13⅝	3½
1⅝	44	35	10	13	4⅜	20½	150	4½	15½	4
1¾	50	41	10	13	4⅜	20½	175	5	18	4¾

EQUALIZING BRIDLE SLINGS WITH FOUR HOOKS
"BLUE CENTER STEEL" ROPE

FIG. 33—SAFE LOADS OF BRIDLE SLINGS WITH FOUR HOOKS



MAXIMUM SAFE LOADS

WHERE ROPE DOES NOT COME IN CONTACT WITH THE MATERIAL HOISTED, AS SHOWN WITH SLING HITCHED TO FLASK. FOR HOISTING UNDER MORE ADVERSE CONDITIONS, SEE B/P "CS-149".

DIAM SLING	SAFE LOAD IN TONS OF 2000 LBS. WHEN USED VERTICAL	WHEN USED 60° ANGLE	WHEN USED 45° ANGLE	THIMBLE A	B	C	D
1/2"	6	5	4	5 1/4"	7 1/4"	2"	11 1/4"
5/8	10	8.5	7	5 1/4	7 1/2	1 13/16	11 7/8
3/4	14	12	10	5 1/4	7 1/2	1 13/16	11 7/8
7/8	20	17	14	6 1/2	8 3/4	2 3/8	14 1/4
1	26	22.5	18	6 1/2	8 3/4	2 3/8	14 1/4
1 1/8	32	28	23	8	11 1/4	2 5/8	17 3/4
1 1/4	38	33	27	8	11 1/4	2 3/8	17 3/4
1 3/8	45	39	32	9	12	3 1/2	19
1 1/2	51	44	36	9	12	3 1/2	19
1 5/8	57	49	40	10	13	4 3/8	20 1/2
1 3/4	65	56	46	10	13	4 3/8	20 1/2

NOTE:- SHACKLES ARE DESIGNED TO SUIT MEMBER HOISTED

SHACKLE BRIDLE SLINGS
GROMMET CONSTRUCTION
"BLUE CENTER STEEL" ROPE

FIG. 34—SAFE LOADS OF BRIDLE SLINGS WITH EQUALIZING THIMBLE AND SHACKLE CONNECTIONS

Fig. 22 illustrates a monorail transfer bridge equipped with a monorail hoist. This bridge is equipped with a latching device which is operated from the hoist cage. The entire unit may be operated as a three-motor traveling overhead crane. The controller for the bridge is placed in the hoist cage so that the bridge can be controlled from the cage. When it is desired to engage a spur track to allow the hoist to run off the bridge, the bridge is latched securely to the track before the hoist is run off. When the crane is engaged with any of the spur tracks, all other tracks are locked by baffle plates, thus preventing any other hoist running out into the crane bay. When the bridge engages the spur track, this baffle is automatically lifted, allowing the hoist to run onto the bridge.

All gearing, with the exception of the truck gears, is enclosed in heavy dust-tight cases and is oil bath lubricated. The bridge is equipped with an electric brake, which automatically stops the travel of the bridge when the power is cut off from the traveling motor. This machine can be installed in the central bay with spurs leading to other parts of the plant and to unloading platform, thus allowing flexibility in the operation and use of a monorail hoist. Fig. 23 shows a Shaw Electric Crane Co.'s monorail as applied in a portion of the J. I. Case Threshing Machine Co.'s foundry at Racine, Wis. One of the unique features of the system illustrated in Fig. 23 is the fixed tongue track switch which is described as follows:

The operation of the fixed tongue switch is equally distinctive, in that under no conditions can it present an open end to the trolley, so that the possibility of an accidental derailment is entirely eliminated. Furthermore, this track-switch does not have to be set for the desired directions of travel; the operator does not have to stop and reach out to "throw" the switch. He selects his route by pulling a lever in the operating cage as he approaches the switch, in the manner to be described. The trolley, therefore, runs through the track switch in any direction without stopping, thus avoiding all loss of time at the switches.

Considering the track layout, it is apparent that the introduction of a track-switch of the moving-tongue type impairs

the continuity of the main track, since the track-switch may at any time be set for the spur track—a contingency for which the operator must be constantly on the alert. With the fixed-tongue system, on the other hand, both routes through the track-switch are always free. For these reasons it is entirely practicable to lay out a track system with as many track-switches of the fixed-tongue type as may be required, located wherever there is occasion to divide or divert the traffic, whereas with the moving tongue type, the introduction of track-switches is restricted by practical operating considerations.

Referring to Fig. 21, it will be seen that the steel castings composing the track-switch are formed with tread flange to correspond with those of the track beam and that these tread flanges are divided into three tongues by the two slots. The trolley has two four-wheel swivel trucks and as it runs through the track-switch one side of each truck passes through one of the switch slots, while the wheels successively cross the other slot. It should be particularly noted that in consequence of the angular position of the slot with reference to the direction of travel, wheels directly opposite each other in the truck do not cross simultaneously and that there are always two diagonally-opposite wheels in proper position to carry the load. As the truck runs through the switch, therefore, the action is the same as if the track were continuous.

Selecting the Route

The manner in which the leading truck is steered onto the spur track is shown in Fig. 24, which is a sectional plan at the level of the lower flange of the I-beam, showing a right hand track-switch and the truck sides of the trolley. When approaching the track-switch with the intention of running onto the spur track, the horizontal roller T_2, located in front of the leading truck and known as the steering tappet, is raised by the steering lever in the cage and engages the curved flange B on the under side of the central tongue of the track-switch. In this manner the leading truck is swiveled and diverted onto the spur track. No steering operation is necessary to return from the spur track to the main track, nor to run through the track-switch in either direction on the main line.

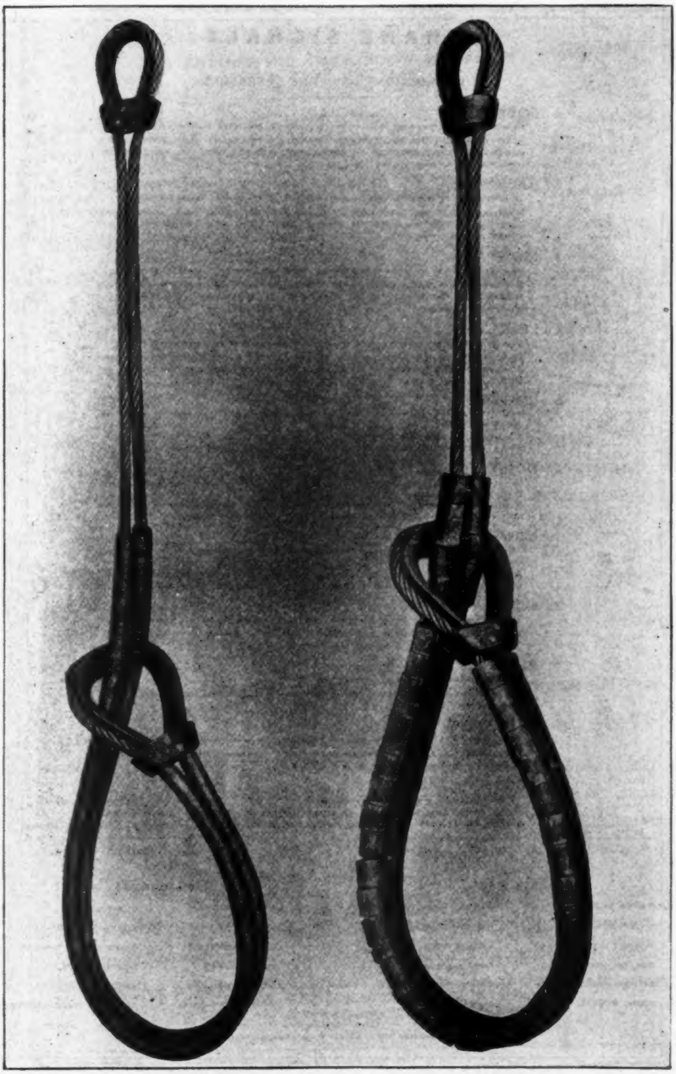
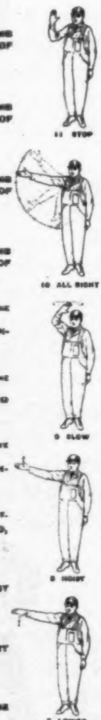


FIG. 35—TWO TYPES OF PROTECTED ANCHOR SLINGS



CRANE SIGNALS

AND

INSTRUCTIONS TO CRANE OPERATORS

1 FORWARD

To move bridge of traveling crane forward or car of locomotive crane forward.

A MOVEMENT, IN THE DIRECTION OF TRAVEL, OF THE RIGHT HAND, WITH THUMB POINTING IN THE DIRECTION OF TRAVEL, OR 2 SHORT AND 1 LONG BLAST OF WHISTLE. - - ——

2 BACKWARD

To move bridge of traveling crane backward or car of locomotive crane backward.

A MOVEMENT, IN THE DIRECTION OF TRAVEL, OF THE RIGHT HAND, WITH THUMB POINTING IN THE DIRECTION OF TRAVEL, OR 2 LONG AND 1 SHORT BLAST OF WHISTLE. —— —— -

3 RIGHT

To move trolley of traveling crane to right or to slue locomotive crane to right.

A MOVEMENT IN THE DIRECTION OF TRAVEL OF THE RIGHT HAND, WITH THUMB POINTING IN THE DIRECTION OF TRAVEL, OR 1 SHORT AND 1 LONG BLAST OF WHISTLE. - ——

4 LEFT

To move trolley of traveling crane to left or to slue locomotive crane to left.

A MOVEMENT IN THE DIRECTION OF TRAVEL OF THE RIGHT HAND, WITH THUMB POINTING IN THE DIRECTION OF TRAVEL, OR 1 LONG AND 1 SHORT BLAST OF WHISTLE. —— -

5 LOWER

To lower the small hook of the traveling crane, or to lower the hook block of the locomotive crane.

A MOVEMENT DOWNWARD OF THE RIGHT HAND WITH THUMB POINTING DOWNWARD, AND WITH HAND CLOSED, OR 1 LONG BLAST OF WHISTLE. ——

6 HOIST

To hoist the small hook of the traveling crane, or to hoist the hook block of the locomotive crane.

A MOVEMENT, UPWARD OF THE RIGHT HAND WITH THUMB POINTING UPWARD AND WITH HAND CLOSED, OR 1 SHORT BLAST OF WHISTLE. -

7 LOWER

To lower the large hook of the traveling crane, or to lower boom of the locomotive crane.

A MOVEMENT DOWNWARD OF THE RIGHT HAND WITH THUMB POINTING DOWNWARD, AND HAND OPEN, OR 2 LONG BLASTS OF WHISTLE. —— ——

8 HOIST

To hoist the large hook of the traveling crane, or to hoist boom of the locomotive crane.

A MOVEMENT UPWARD OF THE RIGHT HAND WITH THUMB POINTING UPWARD, AND HAND OPEN, OR 2 SHORT BLASTS OF WHISTLE. - -

9 SLOW

When required may follow any signal.

RAISE RIGHT ARM AND MOVE VERTICALLY IN A CIRCLE, OR 1 VERY LONG BLAST OF WHISTLE. ————

10 ALL RIGHT

When required to assure crane operator of correctness of crane movement.

WAVE RIGHT ARM UP AND DOWN WITH QUICK RUNNING MOTION, OR 3 SHORT BLASTS OF THE WHISTLE. - - -

11 STOP

To be given at any time to stop all movements.

RAISE RIGHT ARM WITH PALM OF HAND SHOULDER HIGH AND FACING TO THE FRONT, OR 1 SHORT, 1 LONG AND 1 SHORT BLAST OF WHISTLE. - —— -

SAFETY FIRST

WATCH SIGNALS.
WATCH HITCHES.
INSPECT FOLLOWING.
BRAKES, LIMIT STOPS.
CHAINS, CABLES.
HOOK, SHEAVE, DRUMS.
GEARS, TRUCK WHEELS.
RUNWAY TRACKS.
BRIDGE WALK.
CAGE SUPPORT.
BOLTS, NUTS.
SIGNAL DRILL.

ENDURANCE

OIL TWICE DAILY.
CLEAN DAILY
START SLOWLY.
STOP SLOWLY.
DON'T OVERLOAD.
DON'T DRAG LOAD.
DON'T BUMP.
DON'T OVERWIND.
DON'T TAKE A CHANCE.
DON'T FORGET.
REPORT ACCIDENTS.
REPORT STRANGE NOISE.

FIG. 36—CRANE SIGNALS AND INSTRUCTIONS FOR CRANE OPERATORS

WORTHINGTON PUMP AND MACHINERY CORPORATION
DEANE STEAM PUMP PLANT
CRANE INSPECTION REPORT

Make & Capacity of Crane..NORTHERN 10 TON......Mach. No.425.....Date 6-14-17

INSTRUCTIONS TO INSPECTOR. Any dangerous condition shall be indicated by underscoring the report in red and inspector will definitely state whether he considers it necessary to shut down crane immediately or whether it be permitted to operate. He shall follow all repairs vigorously until the machine is right.

ELECTRICAL EQUIPMENT	Commutator or Collector Rings	Air Gap	Brushes	Grounds
Main hoisting motor	SMOOTH	1 - 32"	O.K.	NONE
Auxiliary " "	SMOOTH	1 - 32"	O.K.	NONE
Trolley travel "	SMOOTH	1 - 32"	O.K.	NONE
Bridge " "	SMOOTH	1 - 32"	O.K.	NONE

	Resistance grids	Contacts	Lost Motion
Main hoisting controller	O.K.	O.K.	SLIGHT
Auxiliary " "	O.K.	BURNED	CONSIDERABLE
Trolley travel "	O.K.	BURNED	CONSIDERABLE
Bridge " "	O.K.	O.K.	SLIGHT

LUBRICATION AND MECHANICAL CONDITION

Motor bearings, Main..O.K...Auxiliary..O.K..Trolley..O.K..Bridge..O.K....

Drum " Main.....SLACK..........Auxiliary......O.K.............

Gearing.WORN BUT O.K. FOR PRESENT.......Hooks..IN GOOD CONDITION......

Hoisting cable or chain, Main....GOOD......Auxiliary O.K. BUT SOMEWHAT WORN

SAFETY APPLIANCES

Automatic Stop, Main.TESTED AND FOUND O.K.......Auxiliary.TESTED AND FOUND O.K.

Drum brake, Main.TESTED AND FOUND O.K.......Auxiliary.TESTED AND FOUND OK.

Solenoid brake, Main.TESTED AND FOUND O.K.......Auxiliary.TESTED AND FOUND OK.

Trolley travel brake.........NONE..........Bridge travel brake.TESTED AND FOUND OK.

Runway stops.....BOLTS TIGHT AND O.K..................................

SUGGESTIONS OPERATOR SHOULD KEEP HIS CRANE CLEANER; USE OIL MORE GENEROUSLY ON DRUM BEARING AND LESS ON OUTSIDE. A NEW PINION ORDERED FOR THE MAIN HOIST; A NEW CABLE FOR THE AUXILIARY HOIST AND CONTROLLER CONTRACTS FOR AUXILIARY HOIST AND TROLLEY REPLACED SATURDAY AFTERNOON.

(Signed)..HENRY F. JONES..........
Inspector.

FIG. 37—REPORT OF CRANE INSPECTION

The means whereby the rear truck is compelled to follow the leading truck onto the spur track is indicated in Fig. 26, the main portion of which corresponds to Fig. 24, while the auxiliary portion is a section (drawn to a larger scale) showing the rear truck and a portion of the trolley frame. Lines *L, R* and *F* are the center lines respectively of the leading truck, the rear truck and the trolley frame. When on a curve, the trucks swivel relative to the trolley frame, through an angle denominated *A* in the case of the rear truck and, as indicated in the auxiliary diagram, angle *A* is limited by an adjustable set-screw S_1 in the trolley side R_1. Assuming both trucks to be on the main track and approaching the track-switch, the center lines *L, R* and *F* would then lie in a straight line and angle *A* would be zero. As the leading truck proceeds around the curve of the spur, the trolley frame swings around with reference to center line R of the rear truck and angle *A* increases. When the rear truck reaches the point where the curve begins (approximately the position shown in Fig. 26) the frame castings engage the set-screw S_1 and angle *A* has attained its maximum value. As the trolley proceeds further, the frame castings slews the rear truck around and compels it to follow onto the spur track. It should be particularly noted that this action is positive and independent of the initial steering operation.

The diagram shows a right-hand switch, but it will be noted that set-screws S_2 in the truck side R_2 provides for the left-hand switches. It is of course also understood that the trolley travels either end ahead and that both trucks embody the steering feature and the set-screws.

Locomotive Cranes

Unloading sand and the disposal of foundry refuse is an important item in the cost of operating a foundry and may be frequently reduced by the use of a locomotive crane. A locomotive crane of 15-ton capacity at about 15-foot radius and 5-ton at about 42-foot radius is adapted for a foundry of 50-ton daily capacity. A purchaser should invariably purchase an 8-wheel crane mounted on a specially constructed, exceptionally heavy truck built of structural steel shapes and conforming to Master Car Builders' specifications. Such a machine will cost

in normal times about $12,000, at present $18,000, and should be equipped with the following additionals:

One yard chain bucket....................	$ 800.00
One 45-inch magnet........................	1400.00
7½-kilowatt turbine generator.............	800.00

A locomotive crane and grab bucket, as shown in Fig. 25, illustrating a Brown Hoisting Machine Co. locomotive crane and bucket, can unload a 40-ton carload of sand in 30 minutes. The same equipment may also be used for unloading coal and coke at a considerable saving over the usual hand methods.

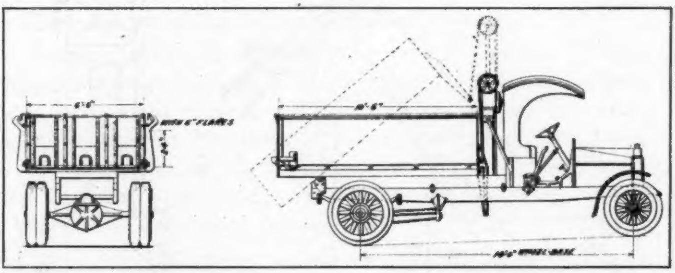


FIG. 38—TRUCK WITH STEEL DUMP BODY AND HYDRAULIC HOIST

A 40-ton carload of pig iron or scrap may be unloaded in 50 to 60 minutes with a locomotive crane equipped with a lifting magnet, as illustrated in Fig. 29. Figs. 27 and 28 show other representative views of lifting magnets used in connection with cranes. These figures illustrate the obvious saving resulting from the use of lifting magnets in connection with the locomotive and traveling cranes.

Crane Operation and Maintenance

The use of cranes and hoisting devices require careful thought and attention. All chains and cables should be inspected regularly and carefully for flaws or defects. Sling chains of suitable strength should always be used. Selection is usually left to the judgment of the employe making the hitch. A

method to train him and provide him with information so that he will know just what he is doing was devised by F. W. Salmon and described as follows in the *American Machinist* of January 16, 1916:

"The illustration (Fig. 30) shows a gage by which the safe load on a chain or wire-rope sling may be obtained for any angle of sling from the vertical to 60 degrees, by either placing the gage against the sling, as shown, or holding it at a distance at such an angle that its upper edge coincides with the axis of the sling part. It is suitable for all the usual sizes of chain or wire rope, provided they are in good condition.

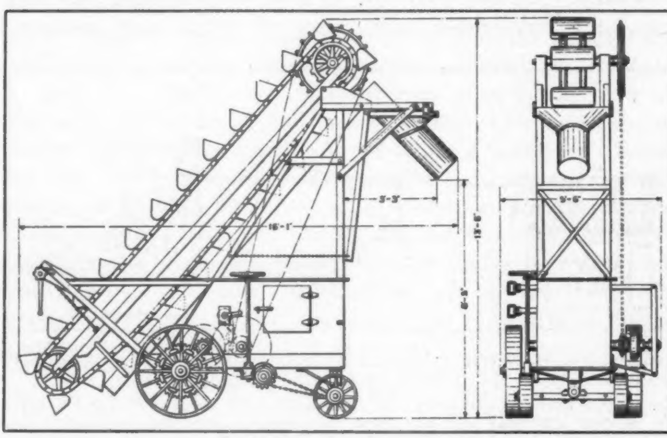


FIG. 39—TRUCK LOADER FOR CRUSHED STONE, SAND AND SIMILAR MATERIALS

"It is simply a light, seasoned-wood frame *A*, about 1 foot long and ¾-inch thick, cut out on a jig-saw. In the center of this frame is freely suspended a small, heavy pendulum. Transparent celluloid is put on each side of the frame, and on this are marked the graduations for the safe loads for chains on one side, for ropes on the other.

"The very fact that such an instrument is in the shop and frequently used will lead the men to be more careful, give them a better idea of the effect of the angles on sling chains, and lead them to become better informed on the strength of slings and the weights of the pieces commonly lifted."

At the Deane works of the Worthington Pump & Machinery Corp., each sling is marked with its capacity as indicated

in Fig. 31, and this with other similar precautionary measures has established a record of no serious accidents from the use of hoisting apparatus. Figs. 32, 33 and 34 are reproduced from John A. Roebling's Son catalog and give similar data with the reference to the use of steel rope slings. Fig. 35 shows a type of sling in which the wire is armored or protected against direct contact with the object lifted.

Sometimes a frequent and just criticism of many molders is inadequate and poor crane service. Crane service may be improved by the use of standard signals and suitable instructions to crane operators. As a suggestion, the crane signals in use at the Deane works of the Worthington Pump & Machinery Corp., shown in Fig. 36, are submitted.

Another cause of improper service of cranes is their frequent stoppage for repairs. Cranes constructed and designed along the lines of those described should have very few stoppages for repairs. However, to guard against such stoppages, the Deane works of the Worthington Pump & Machinery Corp. has used to advantage the crane inspection report shown in Fig. 37, which is filled out weekly.

Ultimately, the state board of labor and industries of Massachusetts and other states, may require the foundries to fill out a similar report for all cranes and hoisting equipment. To further establish the safety of cranes, the code of safety standards for cranes of the American Society of Mechanical Engineers should be thoroughly studied and the practice there recommended, used. "Safe Practices," published by the National Safety Council, Vol. I, No. 6, is a valuable treatise on the practical and safe application of the use of ropes, cables and chains.

Foundry sand, especially core sand and sand refuse, may frequently be handled conveniently by an automobile truck equipped with a dumping body similar to that illustrated in Fig. 38. A 5-ton truck of this type will cost, equipped, about \$4500; will make 12 to 15 miles per hour and may be unloaded almost instantly and loaded in three to four minutes with a gas engine or motor-operated loading machine similar to that shown in Figs. 39 and 40, which costs from \$900 to \$1000.

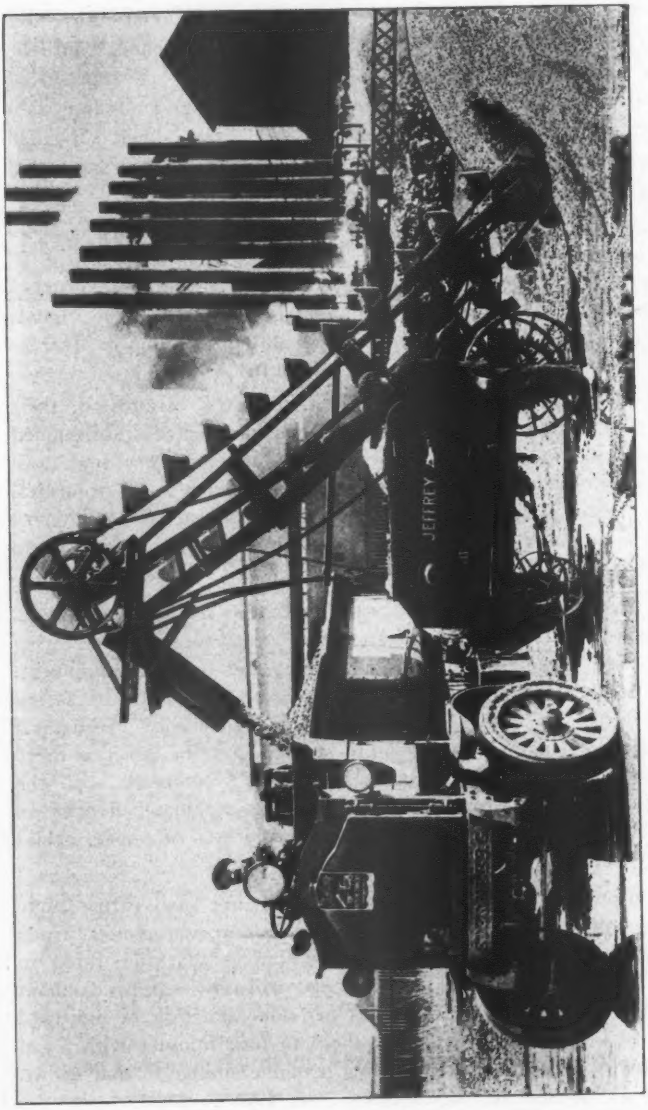


FIG. 40—PORTABLE WAGON LOADER CAPACITY ONE TON PER MINUTE

Belt and bucket conveyors have been used to some extent in foundries, especially two-story foundries and continuous pouring foundries. The expense, however, is usually too large for them to be considered for the foundry doing the usual class of jobbing work, and therefore, I have not shown illustrations depicting the use of the belt or bucket conveyors.

The foregoing suggestions on the use and the operation of hoisting and conveying devices have proved of value and merit careful thought for foundrymen endeavoring to stem the rising tide on operating costs.

Report of the A. F. A. Committee on Safety, Sanitation and Fire Prevention

When the committee on safety and sanitation submitted its report at the convention in Cleveland in 1916, the National Founders' association, through H. J. Boggis, requested a joint conference between the American Foundrymen's association safety committee and the safety committee of the National Founders' association. President J. P. Pero was appointed to confer with President W. H. Barr of the National Founders' association and with H. D. Miles. Owing to pressure of business, Mr. Pero was unable to meet with Mr. Barr and requested the chairman of the safety committee to act in his place in the conference with Mr. Barr. This joint conference was held at Buffalo on July 30. There were present at this conference W. H. Barr, H. D. Miles, D. W. Sowers of the Sowers Mfg. Co., Buffalo, and Victor T. Noonan, chairman of the safety committee of the American Foundrymen's association.

The result of this joint meeting was that a suggestion was made that the American Foundrymen's association abandon its foundry code and adopt the foundry code of the National Founders' association. If this step were taken, the National Founders' association would adopt the sanitary requirements which are a part of the American Foundrymen's association code.

Mr. Alexander's suggestions were submitted to the A. F. A. Committee on Safety and Sanitation, at a meeting held at Buffalo, Aug. 17, this year, and the action of this committee is shown in the following resolution, which was unanimously adopted:

> The Committee on Safety, Sanitation and Fire Prevention of the American Foundrymen's association, after carefully going over the proposed foundry regulations of

the various states, such as New York, Pennsylvania and Ohio, and also after carefully reviewing the foundry code of the National Founders' association, unanimously recommends that the American Foundrymen's association code, as herewith submitted, be adopted by the American Foundrymen's association as the standard foundrymen's code.

We have gone over this code for the third time and have made a number of refinements and rearrangements of the text, and we ask that this code be given desired publicity, particularly for legislative investigation.

Victor T. Noonan, *Chairman*
Director of Safety, Industrial Commission of Ohio, Columbus, O.

F. H. Elam,
American Steel Foundries, Chicago.

George B. Koch,
Pennsylvania Railroad Co., Altoona, Pa.

Dr. Richard Moldenke,
Watchung, N. J.

Earl B. Morgan,
Norton Co., Worcester, Mass.

Thos. J. Soults,
Sill Stove Works, Rochester, N. Y.

C. E. Pettibone,
Pickands, Mather & Co., Cleveland.

F. H. Wentworth,
Fire Prevention Bureau, Boston.

Ralph H. West,
West Steel Castings Co., Cleveland.

W. G. Kranz,
National Malleable Castings Co., Cleveland.

Proposed American Foundrymen's Association Safety and Sanitation Code

Rule A—Definition

1.—A "foundry" shall mean a place where any metal, alloy or composition is melted and poured into molds for the making of castings.

Rule B—Entrances

1.—The term "entrances" shall mean passages for common use provided for employes during working hours, between the foundry and open air.

2.—Entrances to foundries shall be protected by a covered vestibule or its equivalent, which shall be so constructed as to eliminate drafts and of such dimensions as to answer ordinary purposes, such as the passage of wheelbarrows, trucks and small industrial cars. This rule shall not apply to entrances used for railroad or industrial cars handled by locomotives or motors, or for traveling cranes, horse-drawn vehicles or automobiles; these entrances may remain open for such time as is necessary for the ingress and egress of such cars, trucks and cranes, horse-drawn vehicle or automobiles. No locomotive shall be permitted to remain inside the foundry during the loading or unloading of the cars.

Rule C—Gangways

1.—The term "gangways" shall mean well defined passageways dividing the working floors of foundries, but not the spaces between molds.

2.—Gangways other than those for carrying molten metal shall be of sufficient width and properly illuminated to safely allow the passage of men and materials. They shall be kept free from obstruction at all times.

3.—Main gangways where metal is carried by hand or buggy shall be of sufficient width to allow the passage of two ladles going in opposite directions, with an additional side clearance of six (6) inches.

4.—Main gangways for crane ladles shall be wide enough to allow a clearance of eighteen (18) inches on each side of the largest ladle used, except in such cases where ladles are carried with a clearance of at least six (6) feet above the floor.

Rule D—Aisles

1.—Spaces between molds shall be divided into three classes, which shall be known as "hand-ladle" aisles, "Buggy-ladle" aisles and "crane-ladle" aisles.

2.—Hand-ladle aisles—when a ladle is carried by one (1) man shall be of sufficient width to allow two (2) men to pass.

3.—Hand-ladle aisles—when ladles are carried by more than two (2) men—shall be wide enough to allow two (2) men to walk abreast, with an additional total clearance of six (6) inches.

4.—Buggy-ladle aisles shall be of sufficient width to accommodate the ladle with a clearance of six (6) inches on each side.

5.—Crane-ladle aisles—leading from the gangway to all molds shall have a net clearance of at least 18 inches for molds 2 feet high and 24 inches for molds over 2 feet in height.

6.—During the progress of casting, every gangway or aisle shall be kept entirely free from pools of water or obstruction of any nature. Every gangway where industrial tracks are used shall be constructed of a hard material of substantial character, and the top of the rails shall be flush with the floor.

Rule E—Core Rooms

1.—All regulations pertaining to the foundry such as heating, lighting, ventilating and sanitation shall apply equally to the core room.

2.—When core ovens are located in the same room in which the cores are made, the temperature of that part of the room devoted to coremaking shall not exceed one hundred (100) degrees Fahrenheit.

3.—Separate working space shall be provided where females are engaged in the making of cores.

4.—No female employed in any coremaking room shall be permitted to handle cores having a temperature in excess of one hundred ten (110) degrees Fahrenheit.

Rule F—Cleaning and Finishing Operations

1.—All castings shall, where practicable, be cleaned or shipped in rooms separated from those used for other purposes; but where castings are cleaned or shipped in molding or casting room, there shall be provided suitable screens, partitions, or other effective means to protect employes against flying chips or excessive dust.

2.—When finishing rails or benches are used, these must be sufficiently far apart to allow the operatives to pass between them without being endangered by falling castings.

3.—All cleaning and finishing floors shall be cleaned and leveled daily to insure safe working conditions.

4.—When dry tumbling mills are used exhaust apparatus shall be installed and operated that will effectively draw off the dust created by the operation of such mills; or the mills shall be enclosed in reasonably dust-tight compartments while in operation.

5.—Where dry grinding, buffing or polishing machines are used, exhaust apparatus or its equivalent shall be installed and operated that will effectively remove the dust created by the operation of such machines. This rule shall not apply to floor or bench stands used especially for grinding.

6.—Where swing frame or portable buffing, grinding or polishing machines are used, screens shall be provided to protect adjacent workmen.

7.—All abrasive wheels shall be provided with protection hoods adapted to a proper presentation of the work and be mounted with compression blotters and with relieved flanges, at least one-half the diameter of the wheel.

8.—Sand-blasting by hand-operating apparatus shall be carried on in dust-proof rooms. Effective means shall be provided to protect passers-by from the sand-blast. Sand or shot blast operatives shall be provided with suitable helmets

or masks, respirators, approved safety goggles, gloves and leggings. Dust shall not be exhausted into the open air, but shall be confined in a collector.

9.—All men engaged in the cleaning and finishing departments shall be provided with approved safety goggles.

10.—All tools shall be kept free from mushroomed heads and kept properly dressed.

11.—All chisel and hammer handles shall be properly fitted and provided with safety wedges.

12.—All electric arc welding shall be properly enclosed to prevent egress of light rays. Such enclosures shall be properly ventilated.

13.—The operatives shall be provided with approved masks, gloves and slow combustion aprons.

14.—The use of high explosives is absolutely prohibited on the foundry premises.

15.—The breaking of castings by the use of a drop inside the foundry during the general working hours is prohibited. When a drop is used for the breaking of castings or scrap outside of the foundry, a permanent shield of heavy planking or other protection shall be provided.

16.—Every employe in every foundry shall use the devices furnished for his protection by his employer where there is a hazard connected with his employment.

Rule G—Equipment

1.—The floor beneath and immediately surrounding a cupola shall be kept free from collection of water.

2.—All pits or openings located in foundry floors shall be guarded by suitable covers or railings or by watchmen.

3.—All ladles pouring from the lip, of two thousand (2000) pounds or over capacity, shall be equipped with a worm-geared device for tilting them.

4.—All crane, truck and trolley pouring ladles shall be so constructed that the center of gravity shall be below the trunnion, and shall be equipped with a dog to prevent it from overturning.

5.—All single shank hand ladles shall be provided with sheet metal guards.

6.—Where the crown plate of an upright crucible furnace is elevated above the surrounding floor in excess of twelve (12) inches, the furnace shall be equipped with a platform having a standard rail; such platform shall be constructed of metal or other fireproof material, and shall extend along the fronts and sides of the furnace, flush with the crown plate, and shall be at least four (4) feet in width, and shall be clear of all obstructions during pouring time. If the platform is elevated above the floor in excess of twelve (12) inches the lowering from same of crucible containing molten metal shall be by mechanical means.

7.—When the combined weight of crucible, tongs and molten metal exceeds one hundred (100) pounds, it shall be removed from furnace by two men, or mechanical means, and deposited on the floor.

8.—Equipment used for the movement of materials by overhead cranes, such as sand buckets, shall be of substantial construction. When buckets have movable bails, safety locks or catches shall be provided, and the use of such locks must be enforced.

9.—Substantial cast steel handles shall be provided on grab buckets to afford safe means of pulling or prying apart the jaws in case the cylinders stick.

10.—All equipment such as sand mills, tumblers, etc., shall have gears, belts and all movable parts safely guarded.

11.—All gears, including trolley gears, couplings, keys, set screws and other movable parts shall be completely enclosed by guards, so constructed as to afford easy access for inspection and repairs. Guards shall be strong enough and properly attached to cranes to catch and prevent the falling of the parts which are guarded.

12.—Foot-walks extending the entire length of the crane bridge girders on the line shaft side shall be of substantial construction, rigidly braced to eliminate vibration, having standard railing and toe boards to prevent the falling of workmen and tools, and provide a safe and adequate means of travel about cranes.

13.—Crane-cages shall be securely fastened to the bridge girder and when molten metal is carried shall be enclosed

with noncombustible material to a height of 3 feet 6 inches above the floor, otherwise a standard railing and toe board are sufficient.

14.—Fenders shall be provided on all crane and carriage and trolley wheels. These fenders shall be of such shape that they will tend to push a man's hand, arm or leg away from the wheel.

15.—In all new construction clearances between crane-walks, cages, etc., and the building walls and roof-trusses shall be ample to insure the safety of cranemen and repairmen.

16.—Suitable electrical or mechanical brakes shall be provided to insure the safe movement of cranes and loads.

17.—All cranes shall be provided with a safety lock switch box so that the electric control of the crane can be locked in the off position during inspection and repairs.

18.—All overhead cranes shall be provided with good strong foot gongs to warn workmen of the passage of overhead loads.

19.—The practice of riding chain and crane loads shall be prohibited.

20.—The swinging or dangling of loose crane chains as the crane moves down the floor shall be prohibited. In case it is necessary to move the crane along the floor with the chains dangling, the ends must be guided by chainmen walking beneath.

21.—All jib cranes shall be mounted on substantial foundations, and securely anchored to the building. All gears and moving parts shall be guarded.

22.—All sling beams shall be securely suspended from jib crane hooks, and guards shall be installed on the hook to prevent the beams from jumping out of the hooks. Sling beams shall be so constructed that the slings cannot jump off the beam, and can be readily moved to accommodate different size flasks.

23.—Slings of all kinds shall be constructed of material of proper quality and sizes to insure at all times a safety factor of 10.

24.—Safe means of access to all crane cabs shall be provided for.

Rule H—Inspection

1.—All ladles, ladle shanks, crucibles, crucible shanks, crucible tongs, yokes, skimmers, slag hoes, crane chains, cables, ropes and slings shall, prior to their use, be inspected in regard to their safe condition by the men preparing and using such appliances.

2.—An inspection in regard to the safe condition of all hoisting apparatus and accessories shall be made at least once a month by a man designated by the employers for the purpose, and a record kept of such inspection.

Rule I—Ventilation

Removal of Smoke, Steam, Gases and Dust

1.—Every foundry shall be so ventilated during working hours that smoke, gases, fumes or dust injurious to the health of employes shall be rendered harmless by means of natural circulation of air, or by ventilating hoods, fans or other effective devices.

2.—Where the operation of drying ladles causes fumes or gases within the foundry, ventilating hoods shall be provided to remove such fumes or gases.

3.—All ovens from which fumes or gases escape shall be provided with hoods of sufficient capacity to remove such fumes and gases.

4.—Foundries in which alloys containing zinc or aluminum are melted or poured shall have a minimum ceiling height of at least fourteen (14) feet. Every furnace shall be provided with ventilating apparatus to effectively remove all noxious fumes and gases. The ceiling of such foundries shall be at least six (6) feet above the outside ground level.

5.—No locomotive shall be permitted to remain inside the foundry during the loading or unloading of the cars.

Rule J—Heating

1.—The temperature in every foundry shall be maintained at not less than fifty (50) degrees Fahr. during working hours in all sections where employes are regularly working.

2.—The use of open salamander stoves shall be prohibited.

Rule K—Lighting

1.—The light in every foundry shall be sufficient to provide safe entrance and exit of employes, and to carry on work safely during working hours.

2.—When natural light is insufficient to properly light the foundry, sufficient artificial light shall be provided.

3.—The continuous use of hand torches or other lamps that emit injurious smoke or gases is prohibited.

Rule L—Sanitation

(a) Water Closets

1.—Water closets shall be provided in every foundry for each sex, according to the following table:

Number of Persons	Number of Closets	Ratio
1 to 10	1	1 for 10
11 to 25	2	1 for 12-1/2
26 to 60	3	1 for 16-2/3
61 to 80	4	1 for 20
81 to 125	5	1 for 25

For every unit of 45 or fractional part thereof in excess of 125 employes an additional water closet shall be provided. Where water and sewage facilities are not available, sanitary chemical closets may be used.

(b) Urinals

1.—Urinals shall be provided in accordance with the following table:

Number of Persons	Number of Urinals	Ratio
1 to 30	1	1 to 30
31 to 80	2	1 to 40
81 to 160	3	1 to 53-1/3

And thereafter an additional urinal to every eighty (80) employed. One individual urinal shall be considered equivalent to two (2) lineal feet of trough or slab urinals.

(c) Washrooms

1.—Wash basins with faucets for hot and cold water shall be supplied for each sex in accordance with the following table:

Number of Persons	Number of Wash Basins	Ratio
1 to 8	1	1 for 8
9 to 16	2	1 for 8
17 to 30	3	1 for 10
31 to 45	4	1 for 11-1/2
46 to 65	5	1 for 13

For each additional twenty-five (25) employes at least one additional wash basin shall be supplied. Twenty inches of enameled sink, or its equivalent in sanitary properties shall be considered the equal of one wash basin.

(d) Shower Baths

1.—Shower baths shall be provided according to the following table:

Number of Persons	Number of Showers	Ratio
1 to 50	1	1 for 50
51 to 100	2	1 for 50
100 to 200	3	1 for 66-2/3
200 to 400	4	1 for 100

For each additional two hundred (200) employes, one additional shower shall be supplied.

(e) Lockers

1.—Individual metal lockers arranged for locking shall be provided for employes, and shall be placed in a separate space for each sex and used exclusively for such purposes. This space may be located in either the washroom, the drying room, or at convenient places in the molding or core room.

(f) Drying Room

1.—Facilities shall be provided, in connection with either locker, wash or toilet rooms for the sanitary drying of workmen's clothes.

(g) Drinking Fountains

1.—Drinking fountains shall be installed at convenient places, and the use of a common drinking cup prohibited.

(h) General

1.—All the above sanitary provisions shall be conveniently located in a place accessible to and connected with the foundry so that entrance thereto can be had without exposure to the open air. General recommendations are given at end of code.

Rule M—Employment of Females

1.—No female shall be employed in a foundry unless upon examination by a physician, it has been determined she is of normal health.

2.—No female employed in any foundry shall lift any object exceeding twenty-five (25) pounds in weight, unless she uses mechanical means by which her physical effort is limited to exertion equivalent to that number of pounds.

Rule N—General Regulations

1.—Regulations affecting industrial establishments generally in respect to the safeguarding of transmission machinery, miscellaneous machinery, elevators, stairways, platforms, chains and cranes, or relating to sanitary conveniences and first aid equipment, not included in this Safety and Sanitation Code, shall apply with equal force to foundries.

2.—When handling molten metal, employes shall wear leggings, congress type shoes, and when possible, goggles.

Recommendations

1.—Accident prevention will be encouraged by the formation of Safety Committees among the men. All foremen must take a personal interest in accident prevention and are expected to set an example of carefulness.

2.—Strict enforcement of workshop regulations is one of the best methods of accident prevention.

3.—First aid kits should contain:—

A—Package done up in waxed paper containing aseptic dressing and bandage for some safe and effective antiseptic, such, for example, as a small vial holding 1 dram of 3 per cent solution of tincture of iodine, together with a camel's hair brush and a bandage.

B—Splints and roll of large bandages.

C—Tourniquet.

4.—It has been proved that 75 per cent of all accidents can be eliminated by educational methods; therefore, the use of bulletin boards, motion pictures, safety meetings and suggestion boxes should be encouraged.

5.—A room shall be provided and kept in a sanitary condition for the employes' use to eat their meals.

Discussion

Dr. Richard Moldenke:—This report is almost the same as the one submitted last year. There are a few changes and improvements. The code of each association was gone over as well as the regulations for Massachusetts, New York, Pennsylvania and Ohio. I am sorry the chairman is not here to defend the report in case there is any criticism. There is a resolution in the report to which I wish to call your attention.

The Chairman, Mr. B. D. Fuller:—You have heard the resolution. May I have a motion for its adoption?

Mr. W. H. Barr (President of the N. F. A.):—Mr. Chairman, I think perhaps it might be advisable for me to explain a little more clearly the part the National Founders' association has taken in the development of rules for safety and sanitation in foundry practice. We are in the industrial field and I think we have studied it as carefully as it is possible to do in any industry. Mr. Chairman, I am going to ask Dr. Moldenke to state how many of the members of the committee were present when this report was prepared and the signature attached.

Dr. Richard Moldenke:—I do not know what Mr. Noonan did about this.

The Secretary, Mr. A. O. Backert:—Mr. Noonan sent a copy of the report to every member of the safety committee and they were returned as being O. K. by each member.

Mr. W. H. Barr:—The N. F. A. rules have been worked on for three years most carefully and exhaustively. Every

feature has been studied and taken care of. Now if you will refer to the first page of the A. F. A. report—I have not been through the whole report—you will notice: "No locomotive shall be permitted to remain inside the foundry during the loading or unloading of cars." What has that got to do with it? What are you going to do with the locomotive when you are operating? I think my criticism has been perfectly just. I am going to close now and I hope you will forgive me if I have spoken frankly. I would like to make a motion. It will have to be a substitute motion for the one offered by Dr. Moldenke and I offer it with his permission. I move that the rules be referred back to the committee of the American Foundrymen's association for conference with the committee of the National Founders' association and they be referred to the next convention.

This motion was seconded.

The Chairman, B. D. Fuller:—The motion has been made and seconded but before voting on it I want you to consider that this has been an exhaustive piece of work. The personnel of our committee speaks for itself. Mr. Noonan is commissioner of the state of Ohio and is chairman of our committee. The A. F. A. and the N. F. A. have been very friendly and have worked in unison and there is no wish for discord at all.

Mr. W. H. McFadden:—I rise to a point of order. Is the gentleman who just spoke a member of our association or is he here as a representative of the N. F. A.?

Mr. W. H. Barr:—I came in behalf of my association.

Mr. W. H. McFadden:—I just raised the point of order to know. I have looked through the list of members and do not find your name. I think it is right to first ascertain whether a man who makes a motion is a member of the association. Mr. Backert has said a copy of the report was sent to each member.

The Secretary, Mr. A. O. Backert:—The committee was unanimous in its decision on this report.

Mr. W. H. Barr:—Does this report as it stands express the sentiment of the A. F. A.? Does it represent the sentiment of the committee? That is the point I want to get some

information on. I will again ask Dr. Moldenke about the members who were present.

Dr. Richard Moldenke:—Those present at the meeting of the committee were Messrs. Noonan, Morgan, West, Elam and myself, so far as I can remember now.

Mr. W. H. Barr:—Perhaps I can clear this thing up. We don't pretend to have a code on safety and sanitation that is perfect. I think it most desirable that foundrymen should unite. The A. F. A. should go over the code of the N. F. A. and vice versa and the conclusions on a safety code should be unanimous.

Mr. R. A. Bull:—What is the motion before the house?

The Chairman, B. D. Fuller:—A motion was made by Dr. Moldenke that was not seconded. I called for a motion to accept the report of the committee.

Mr. R. A. Bull:—Was there a motion made prior to that or one made since that?

The Chairman, B. D. Fuller:—I understand that Mr. Barr is not a member of the association and therefore his motion was not in order.

Mr. George P. Aborn:—I will offer this motion, that the report be referred back to the committee of the A. F. A. in conference with the N. F. A. and that a report be made at the next convention. This is the same motion that Mr. Barr made.

Dr. Richard Moldenke:—Is this a substitute motion or a new motion?

Mr. R. A. Bull:—Has that motion been seconded?

The Chairman, B. D. Fuller:—No, I have not heard a second.

Mr. R. A. Bull:—Before we defer action on this report for another year—it may seem advisable to some that the report be referred to a committee to report tomorrow or Friday. I feel that there are a number of persons here who are interested in this matter and who have not had the opportunity to read the committee's report, and until this is done we cannot intelligently decide what is best to do by simply hearing criticism such as was made by Mr. Barr, without our having read the report. I think all of the members ought to read the report

very carefully. I cannot offer a motion, I guess at this time, but it is my opinion that the suggestion of Mr. McFadden is the one that should be taken. We should not defer action.

The Chairman, B. D. Fuller:—Can't you offer that as an amendment to the motion, Mr. Bull? Is that acceptable to the maker of the motion?

Dr. Richard Moldenke:—I like Mr. Bull's idea. I also feel that the code as presented should be adopted and the committee continued for another year to see if we could not arrive at a single code.

Mr. Charles L. Newcomb:—There ought not to be any differences between the members of the N. F. A. and the A. F. A. Now one year's time would not be very long to have this reconsidered by the committee, a committee which would be selected or continued. The two associations should get together and agree upon the same code. That is what ought to be done. The motion that was made here ought to be carried. You all ought to vote for it. This matter should be put over for another year and should be justly and reasonably considered.

The Secretary, Mr. A. O. Backert:—Mr. Chairman, last year a code was presented at the Cleveland convention, and a representative of the N. F. A. appeared at our meeting and made identically the same demands that we are hearing today. The A. F. A. appreciated the necessity of having one code and only one code and decided to defer action for one year. Mr. H. D. Miles and the president of our association were appointed a committee to represent the A. F. A. for the purpose of unifying the conflicting opinions or statements in the two codes and to prepare one code for submission at this meeting for adoption. Now I know the A. F. A. endeavored for nearly six months to get a meeting with the N. F. A., which it was not possible to arrange until the middle of August. Then the matter had to be gone through hurriedly, and there was no further opportunity for a meeting after the conference held at Buffalo. There was no opportunity for the chairman of our committee to call another meeting to consider the report or the preface to the report. I believe Dr. Moldenke will state that according to his viewpoint it was recommended largely

that the code of the N. F. A. be adopted by the A. F. A. Am I right in that, Mr. Barr?

Mr. W. H. Barr:—Yes.

The Secretary, Mr. A. O. Backert:—And in place of that the A. F. A. brings in a code for adoption believing that there are some good points in its code which might be adopted by the N. F. A.

The Chairman, B. D. Fuller:—Gentlemen, before putting this motion, I want to say this: Several of the gentlemen who have spoken have confessed they have not read this report. They were given an ample opportunity to do so. They have raised no objection until today. The personnel of our committee speaks for itself. Now, gentlemen, I want you to consider this thing carefully. Mr. Aborn, may I ask you to read your motion?

Mr. Geo. P. Aborn:—I have a copy of it here, Mr. Chairman, it is the same motion Mr. Barr made and I will give you the copy to read.

The Chairman, B. D. Fuller:—The motion is, gentlemen, that the rules be referred back to the committee of the A. F. A. for conference with the N. F. A., with instructions to report at the next convention. Gentlemen, that means that if the motion prevails this matter will be referred back for conference with the N. F. A. and put off another year. Are you ready for the question?

Mr. Geo. P. Aborn:—I think this matter should have due consideration even if we have to take it up later. I agree with other speakers that this thing has not been carefully considered and I believe it can be revised. I move that it be referred to a committee and brought up at the next convention.

The Chairman, B. D. Fuller:—I wish to state before putting this motion that in voting aye you vote to defer the work of this committee. Gentlemen, are you ready for the question? Those in favor, say "aye", contrary, "no." The nos have it, the motion is lost.

Mr. R. A. Bull:—I make a motion, Mr. Chairman, that the chair appoint a committee to make a very serious study of this code. We would like to see the gentlemen who are versed on this subject have representation on this committee. I move

that the committee report to this body tomorrow or Friday, whichever day is most suitable, and that they bring their recommendations as to what should be done. I should say Friday so as to give them time for more serious study.

This motion was seconded.

Mr. Freeland:—I want to say a word of caution at this time. I have discovered that the code as worded, and all the codes which the committee had a chance to see, are absolutely like a sieve from a legal standpoint. A lawyer should be consulted so that every section of the code could be notched together.

Dr. Richard Moldenke:—The code is not intended to be forced upon foundrymen as it stands. It is intended for the guidance of legislatures, and they will draft it in the proper form.

The Chairman, B. D. Fuller:—Gentlemen, the motion is that a committee be appointed by the chair to consider this matter and report back its recommendations on Friday.

Mr. R. A. Bull:—That another committee be appointed.

This motion was adopted.

Letter Ballot Provided For

The Secretary, Mr. A. O. Backert:—On Wednesday when the report of the committee on safety and sanitation was presented, some objections were made to some of the provisions of that report and at that time it was decided to appoint a committee to go over this matter. However, the time being too short between Wednesday and Friday to do this, the chairman of the committee, with the consent of the committee members has proposed the following: To meet a similar committee of three of the National Founders' association, and later, after a conference on this safety code question, revision will be made as suggested and the code will go out to the members for letter ballot for adoption.

The Safety Code Revised

The committee provided for in the foregoing discussion met with the representatives of the National Founders' association subsequent to the convention and prepared the joint A. F. A.-N. F. A. safety code which is presented in full on the following pages. This code also has been approved by the members of the American Foundrymen's association in a letter ballot conducted by the secretary.

At the joint meeting for the purpose of harmonizing the two codes the American Foundrymen's association was represented by President Benjamin D. Fuller, Westinghouse Electric & Mfg. Co., Cleveland; Earl B. Morgan, Norton Co., Worcester, Mass., and Ralph D. West, West Steel Castings Co., Cleveland. The National Founders' association was represented by President W. H. Barr, Lumen Bearing Co., Buffalo, and H. J. Boggis, Boggis Foundry Co., Cleveland. A. F. Corbin, Union Mfg. Co., New Britain, Conn., the third member of the National Founders' association committee, was unable to attend the conference.

The revised code has been approved by the A. F. A. special committee of three and by a majority of the members of the A. F. A. committee on safety, sanitation and fire prevention. It also has been approved by the National Founders' association.

Rearrangement of Foundry Code Agreed Upon by Joint Committees, A. F. A. and N. F. A., Buffalo, October 12, 1917

Definition

A1—A "foundry" shall mean a building where iron, steel, copper, tin, zinc, lead, aluminum or compositions containing any of the baser metals are melted and poured into molds for the making of castings, and shall include all molding, coremaking, melting and cleaning rooms used in connection therewith.

Entrances

B1—The term "entrances" shall mean passages for common use between the foundry and open air, provided for employes during working hours.

B2—Entrances to foundries located in cold climates shall be protected during the winter by a covered vestibule or its equivalent, which shall be so constructed as to eliminate harmful drafts, and of such dimensions as to answer ordinary purposes, such as the passage of wheelbarrows, trucks and industrial cars. This rule shall not apply to entrances used for railroad or industrial cars handled by locomotives, or for traveling cranes, horse-drawn vehicles or automobiles; these entrances may remain open during the winter only for such time as is necessary for the ingress and egress of such cars, trucks and cranes, horse-drawn vehicles or automobiles.

Floors and Galleries

C1—The floor beneath and immediately surrounding a foundry cupola shall be kept free from collection of water.

C2—The floor immediately adjoining industrial tracks over which workmen frequently pass shall be reasonably hard and flush with the top of the rails. Sufficient clearance for easy

passage of truck wheels shall be provided between floor and rails.

C3—All pits or openings located in foundry floors shall be guarded by suitable covers or railings or by watchmen.

C4—Galleries where molten metal is poured into molds shall be provided with a solid partition not less than three (3) feet high, installed on the open side of such gallery.

Gangways

D1—The term "gangway" shall mean a well-defined passageway dividing the working floors of foundries.

D2—The width of a gangway or aisle shall be understood to be the clear distance between molds, posts, partitions or other obstructions on one side of the gangway or aisle and similar objects on the opposite side.

D3—Gangways other than those for carrying molten metal shall be of sufficient width and properly illuminated to safely allow the passage of employes and materials. They shall be kept free from obstruction at all times.

D4—Every gangway or aisle in which molten metal is being handled shall, during the progress of casting, be kept in good condition, clear of obstructions and free from undue dampness.

D5—Gangways where molten metal is carried in crane, trolley or sulky ladles, shall be sufficiently wide to allow employes safely to handle and empty the ladles.

D6—Gangways where molten metal is carried on truck ladles exclusively, shall be not less than eighteen (18) inches wider than the extreme width of the truck ladle.

D7—Gangways where molten metal is carried in crucibles by not more than two (2) men per crucible and poured into molds placed on one or both sides of the gangway, shall be not less than three (3) feet wide.

D8—Gangways where molten metal is carried in crucibles by more than two (2) men per crucible and poured into molds placed on one or both sides of the gangway, shall be not less than four (4) feet wide.

D9—Gangways where molten metal is carried in hand or bull

ladles by not more than two (2) men per ladle and poured into molds placed on *both* sides of the gangway, shall be not less than four (4) feet wide.

D10—Gangways where molten metal is carried in hand or bull ladles by not more than two (2) men per ladle and poured into molds placed on only one side of the gangway, shall be not less than three (3) feet wide.

D11—Gangways where molten metal is carried in hand or bull ladles by more than two (2) men per ladle, shall be not less than five (5) feet wide.

Aisles

E1—The term "aisle" shall mean a passageway between molds leading from the gangway.

E2—Aisles where molten metal is carried in hand or bull ladles or crucibles and poured into molds on individual floors by not more than two (2) men per ladle or crucible, shall be not less than twelve (12) inches wide except where molds alongside the aisle are more than twenty (20) inches high above the aisle level, in which case the aisle shall be not less than twenty-four (24) inches wide.

E3—Aisles where molten metal is carried in hand or bull ladles or crucibles and poured into molds on individual floors by more than two (2) men per ladle or crucible, shall be not less than thirty-six (36) inches wide.

E4—Aisles where molten metal is carried and poured into molds on individual floors by cranes, trolley or sulky ladles shall be sufficiently wide to allow employes safely to handle and empty the ladles.

Foundry Equipment

F1—All lip-pouring ladles of two thousand (2000) pounds capacity or more shall be equipped with a worm gear or other self-locking tilting device.

F2—All crane, truck and trolley pouring ladles shall be equipped with a dog to prevent premature overturning and shall be so constructed that when they are full of metal the center of gravity shall be below the center of the trunnion, unless

each ladle is equipped with a gear mechanism and a latch either of which will prevent premature overturning of the ladle.

F3—All single shank hand ladles shall be provided with sheet metal shields.

F4—When the combined weight of a crucible containing molten metal and the crucible tongs exceed one hundred (100) pounds, the crucible shall be removed from the furnace by not less than two men or by mechanical means; and when the combined weight exceeds three hundred (300) pounds, three (3) or more men or mechanical devices shall be employed.

F5—Where the crown plate of an upright crucible furnace is elevated above the surrounding floor in excess of twelve (12) inches, the furnace shall be equipped with a platform having a standard rail; such platform shall be constructed of metal or other fireproof material, and shall extend along the front and sides of the furnace, flush with the crown plate, and shall be at least four (4) feet in width, and shall be clear of all obstructions during pouring time. If the platform is elevated above the floor in excess of twelve (12) inches the lowering from same of crucible containing molten metal shall be by mechanical means.

F6—Equipment used for the movement of materials by overhead cranes, such as sand buckets, shall be of substantial construction. When buckets have movable bails, safety locks or catches shall be provided, and the use of such locks shall be enforced.

F7—Substantial cast steel handles shall be provided on grab buckets to afford safe means of pulling or prying apart the jaws in case the cylinders stick.

F8—The practice of riding chain and crane loads shall be prohibited.

F9—Swinging or dangling crane chains must clear all possible obstructions when the crane is in motion or they must be guided by chainmen walking beneath.

F10—Sling beams shall be so constructed that the slings cannot jump off the beam, and so that the slings can be readily moved to accommodate different size flasks.

F11—Trunnions on flasks hereafter constructed shall be carefully designed for the loads they are to handle and constructed with a factor of safety of at least ten (10) including bolts where they are used. The diameter of the button shall be equal to the diameter of the groove plus one and one-half times the diameter of the sling used to handle the flask. Inside corners shall be well filleted and in order to prevent the sling slipping off or riding the button, the radius of the corner between groove and button shall be approximately equal to the radius of the sling used, the remainder of the inside edge of the button to be straight.

F12—All slings used to suspend flasks from jib crane beams shall either be designed so that there is safe clearances for a hand grip or handles shall be provided to hold the sling.

F13—All ladles, ladle shanks, crucibles, crucible shanks, crucible tongs, yokes, skimmers, slag hoes, crane chains, cables, ropes and slings used in handling or pouring of molten metal shall be inspected daily in regard to their safe condition by the men preparing and using such appliances. A monthly inspection in regard to the safe condition of all crane chains, cables, ropes and slings used for suspending molten metal in mid-air shall be made by a man designated by the employer for the purpose. Written report of such monthly inspections shall be kept.

Finishing and Cleaning

G1—All castings shall, where practicable, be cleaned or chipped in rooms separated from rooms used for other purposes; but where castings are cleaned or chipped in molding or casting rooms, there shall be provided suitable screens, partitions or other effective means to protect employes against flying chips and excessive dust.

G2—When finishing rails or benches are used, these must be sufficiently far apart to allow the operatives to pass between them without being endangered by falling castings.

G3—All cleaning and finishing floors shall be cleaned and leveled as often as necessary to insure safe working conditions.

G4—Where dry tumbling mills are used within a foundry,

exhaust apparatus shall be installed and operated that will effectively draw off the dust created by the operation of such mills, or the mills shall be enclosed in reasonably dust-tight compartments while in operation.

G5—Where dry grinding, buffing or polishing machines are used, an exhaust apparatus or its equivalent that will effectively remove the dust created by the operation of such machines shall be installed and operated. This rule shall not apply to floor or bench stands used especially for tool grinding or portable grinders.

G6—Where swing frame buffing, grinding or polishing machines are used, screens shall be provided when necessary to protect adjacent workmen.

G7—Sand-blasting by hand-operated apparatus shall be carried on in suitable sand-blast rooms or outside the foundry, and in both cases effective means shall be provided to protect passers-by from the sand-blast. Dust shall not be exhausted into the open air but into a collector.

G8—All tools shall be kept properly dressed and free from mushroomed heads.

G9—All electric arc welding shall be properly enclosed to prevent egress of light rays, when carried on during working hours. Such enclosure shall be properly ventilated.

G10—The use of high explosives or of a drop for breaking scrap shall not be permitted unless done under reasonably safe conditions.

Protection Devices

H1—When the dust arising from cleaning operations may be injurious to the health of cleaners, they shall wear suitable respirators which shall be provided by the employers; when engaged in sand-blasting by hand apparatus, they shall in addition wear suitable helmets or hoods which shall be provided by the employer. When the eyes of the employe are liable to injury by dust, flying chips or molten metal employes shall wear suitable safety goggles which shall be provided by the employer. When engaged in welding or burning operations by means of an oxy-acetylene or other gas torch, employes

shall wear suitable safety goggles which shall be provided by the employer; when engaged in similar operations by means of an electric arc, employes shall use suitable shields or wear suitable helmets which shall be provided by the employer. In both these operations employes shall wear slow combustion aprons or overalls which shall be provided by the employer. When handling molten metal, employes shall wear suitable congress-type shoes which shall be provided by themselves; they shall also wear suitable leggings when these are provided by the employer.

Lighting

I1—The light in every foundry shall be sufficient to provide safe entrance and exit of employes, and to carry on work safely during working hours.

Heating

J1—The temperature in every foundry shall be maintained at not less than fifty (50) degrees Fahrenheit during working hours in all sections where employes are regularly working.

Ventilation

K1—Every foundry shall be so ventilated during working hours that smoke, gases, fumes or dust injurious to the health of employes shall, as far as practicable, be rendered harmless by means of natural circulation of air or by ventilating hoods, fans or other effective devices.

K2—Where the operation of drying ladles causes fumes or gases injurious to the health of the employes within the foundry, ventilating hoods shall be provided to remove such fumes or gases.

K3—All ovens from which fumes or gases injurious to the health of employes escape shall be provided with hoods of sufficient capacity to remove such fumes and gases.

K4—No locomotive while discharging smoke shall remain inside a foundry during working hours except during such periods as may be necessary for its entrance and exit; but this regulation shall not apply to locomotive cranes or steam charging machines.

K5—No foundry in which zinc-bearing metals are melted or poured shall hereafter be installed in a room less than fourteen

(14) feet in height from the lowest point of the ceiling to the floor, except that where the roof is of peak, saw-tooth, monitor or arch construction, the minimum height of the side walls may be twelve (12) feet. If such foundry is installed in the front part of the building the ceiling shall be in every part not less than six (6) feet, six (6) inches above the curb level of the street in front of the building, and if such foundry is installed entirely in the rear part of a building or extends from the front of a building to its rear, the ceiling shall not be less than three (3) feet above the curb level of the street in front of the building and the foundry shall open on a yard or court which shall be not less than six (6) inches below the level of the floor.

K6—If after this safety-code is approved the operation of any foundry in which zinc-bearing metals are melted or poured shall be discontinued for not less than fifteen (15) consecutive days, it can thereafter be reopened for the same purpose only by complying with the provisions of Section K5.

Employment of Females

L1—No female shall be employed in a foundry unless upon examination by a competent nurse or physician it has been determined that she is of normal health, size and weight.

L2—No female employed in a foundry shall lift any object exceeding thirty-five (35) pounds in weight unless she uses mechanical means by which her physical effort is limited to thirty-five (35) pounds.

General Regulations

M1—Regulations affecting industrial establishments generally in respect to the safeguarding of transmission machinery, miscellaneous machinery, elevators, stairways, platforms, or relating to sanitary conveniences and first-aid equipment, not included in this code, shall apply with equal force to foundries.

Suspension of Regulations

N1—This code may be modified or suspended in whole or in part by the proper state authority in respect to existing foundries if good and sufficient reason therefor is submitted.

RECOMMENDATIONS

O1—Accident prevention will be encouraged by the formation of safety committees among the men. All foremen should take a personal interest in accident prevention and are expected to set an example of carefulness.

O2—Strict enforcement of workshop regulations is one of the best methods of accident prevention.

O3—It has been proved that 75 per cent of all accidents can be eliminated by educational methods; therefore, the use of bulletin boards, motion pictures, safety meetings and suggestion boxes should be encouraged.

O4—First-aid kits should contain:

One two-ounce bottle castor oil, for eye irritations.

Two three-ounce tubes burn ointment (3 per cent bicarbonate of soda in petrolatum).

One two-ounce bottle 3 per cent alcoholic iodine as an antiseptic for injuries that bleed.

One two-ounce bottle of white wine vinegar, for nose bleed and as a neutralizing agent for alkaline burns.

One two-ounce bottle 4 per cent aqueous boric acid, an antiseptic eye wash.

One two-ounce bottle aromatic spirit of ammonia, for headache, nausea, dizziness, heat prostration, and where spirituous liquors would otherwise be used.

One two-ounce bottle Jamaica ginger, 73 per cent alcohol, 25 per cent ginger, for cramps, bowel pains, chills, etc.

One piece of flannel, 24 x 36 inches, for use as a soft bandage.

One and one-half ounces of absorbent cotton, in roll.

One 3-inch x 10-yards gauze bandage.

One 2-inch x 10-yards gauze bandage.

Two 1-inch x 10-yards gauze bandage.

One spool, 1 inch x 5 yards, adhesive plaster.

Six sealed packages, 6 x 36 inches, sterile gauze.

One tourniquet.

One pair scissors.

One pair tweezers.

One triangular sling.
One wire gauze splint, for fractures.
Twelve assorted safety pins.
One teaspoon.
One metal cup.
One medicine glass.
Two medicine droppers (one for boric acid, one for castor oil).
Three paper drinking cups.
Supply of first-aid record cards, for notifying doctor or other responsible party of any wounds dressed by first-aiders, to assure follow-up attention.

O5—A room should be provided and kept in sanitary condition for employes' use to eat their meals.

Refractory Materials Employed in the Metallurgical Industries

By H. C. Arnold, Urbana, Ill.

The questions which confront us in a study of refractories are: What constitutes a refractory? How did the need of such a substance develop? What substances, occurring in nature abundantly, possess most of these properties? How, if at all, can these substances be prepared or treated artificially so that they will fulfill the requirements that they lack? We can arrive at an answer to these questions most satisfactorily by first investigating the technical developments which led to the need of refractories.

Early in the history of metallurgy it was found that metals could be obtained from their compounds by reactions carried on at high temperatures which would not proceed under normal conditions. This fact led to the demand for a container in which such reactions could take place at high temperatures, but which would be entirely resistant to the action occurring and the heat developed. The early workers in metal used natural-occurring clays and clay mixes in fashioning their crucibles, cupelling furnaces and hearth furnaces. Thus, early in the history of metallurgy it was found that natural-occurring clays possessed this property of resistance to heat. With the nineteenth and twentieth century developments in metallurgical processes, the demand for refractories of a definite nature has increased. The other required properties also have increased to include not only resistance to high temperature, but quickly changing temperature, resistance to the metal, and the slag produced, the action of flames and gaseous productions of combustion, resistance to an abnormal abrasive action, and possession of high compressive strength. A refractory, in its application to metallurgical work, may be defined, then, as any substance

applied as a lining or a container, which resists the action of heat, and other actions occurring during the operation.

Qualifications of Good Refractories

No substance used possesses all the required properties, but combinations of substances have been determined which can be used. Up to the present those materials found best suited are compounds of alumina, silica, lime, magnesia, chromic oxide, carbon and a few metals, such as nickel and platinum. These substances may be used singly or in combination as compounds. Usually they do not possess all of the properties required of a refractory alone, and must be mixed, or used in the form of a compound.

The selection of a refractory, and even the design of a furnace itself, will depend largely upon the nature of the slag formed and the temperature required. Slags, depending upon the quantity of silica present, can be divided into acid, neutral and basic. Those which possess an acid nature will tend to react with bases to form a neutral salt; those high in bases will react with acids to produce a neutral salt. A basic slag would attack an acid refractory and dissolve enough of the lining to produce a neutral salt; and vice versa, an acid slag would attack a basic lining. Because of this nature of slags and the necessity of resisting any such corrosive action, refractories are produced of three different characters—acid, basic and neutral.

The acid refractories consist of those high in SiO_2, such as ganister and quartzite which occur in nature, and preparations of these substances either in the mass or as silica brick. The basic refractories include magnesium carbonate and dolomite, a mixture of magnesium and calcium carbonates. The neutral refractories make up the largest division and include the fire clays, pure or nearly pure alundum, which is prepared from bauxite, silicon carbide compounds, carbon, chrome iron ore and various others.

Uses of Acid Refractories

The acid refractories are those high in silica which possess a high melting point. Such materials occur abundantly in nature. Quartzite, or ganister, sandstone, granite, gneisses and

rhyolites—all have been used in the linings of furnaces in the natural state. Large blocks were cut from the mineral, trimmed to shape and used as linings. They were completely resistant to the action of the heat, but did not possess the other properties required for good refractory linings. Rapid heating and cooling caused splitting, cracking and spalling. High quartz materials on heating suffered permanent expansion beyond their normal expansion due to heat changes. They find application where expansion can take place with no harmful results. At present the natural rock is used as a quartzite cement and mortar in sintered bottoms of open-hearth furnaces, and copper reverberatory furnaces. The natural blocks, however, have given way to the artificially prepared quartzite or silica bricks in the roofs and side walls.

The quartzites of commercial importance in America are: The Medina, of Huntingdon and Blair counties, Pa.; that of the Baraboo district, Wisconsin, and the eastern Alabama deposits. The analyses are:

	Medina Quartzite Per Cent.	Baraboo Quartzite Per Cent.	Alabama Quartzite Per Cent.
Silica	97.80	97.15	97.70
Alumina	0.90	1.00	0.96
Iron oxide	0.85	1.05	0.80
Lime	0.10	0.10	0.05
Magnesia	0.15	0.25	0.30
Alkalies	0.40	0.10	0.31

All quartz rocks or substances high in silica will not make good silica brick. Not only chemical composition, but also physical properties, such as structure, fusibility and action as to expansion during burning, have their effect on the final structure of the brick. Chemically, the quartzites must be high in silica, low in alkalies, but contain enough fluxing impurity to give the brick produced a bond. This impurity is usually an alumina and iron oxide content. The composition should range between 96 and 98 per cent silica, 1.75 to 2.5 per cent alumina and iron oxide, very little lime and magnesia, and less than 0.5 per cent alkalies.

The melting point of quartzite will depend to a certain extent on the composition, and accessory minerals. With increase

in bases, the melting point decreases. Pure quartzite has a higher melting point than the quartzites used commercially, but does not produce a good sound brick and will not have the physical strength required in metallurgical work. The melting or softening point varies from 3290 to 3360 degrees Fahr. Good quartzites must have a high melting point, although those having the highest will not make the best brick.

The structure of the rock is of considerable importance. The quartzites used in this country are hard, splintery rocks which break down to angular fragments having no rounded grains. Sandstones of equal purity chemically, because of the roundness of the grain, cannot be used in the production of brick.

Probably the most important test on a quartzite is the expansion on heating. The permanent expansion may take place largely in the first burn, and to a very small extent in successive burns; or may have a very small value in the first burn and large values after that. The purer quartzites show high expansion or nearly complete expansion in the first burns and relatively little expansion on succeeding burns. The impurer quartzites require somewhat longer time in coming to complete expansion, while the impure sandstones, quartz-schists, etc., show a low expansion on the first burn, and increasing expansion in successive burns. Such results would indicate that, if we could use the purest quartzites and burn them to a high temperature and hold them there until expansion was complete, we would not be troubled with permanent expansion on brick after they have been placed in the furnace. The transformations which occur in the furnace wall after it has been built would then take place in the kiln of brick which is being held at a high temperature, and the only expansion which would occur would be the temporary thermal expansion. Study with the microscope has shown such expansion to be due to a transformation in the form of the silica from quartz to cristobalite. The transformation occurs largely in the first burn, to some extent in the second and less or not at all in the third. A brick of 100 per cent quartz on conversion to cristobalite would suffer an increase in volume of 13.6 per cent. However, although the reaction in a silica brick indicates the development

of cristobalite, not cristobalite but tridymite is the stable form of silica at the temperature at which silica brick are used. Tridymite develops from the cristobalite on repeated heating of the brick and is a much slower conversion than quartz to cristobalite. The conversion of quartz to cristobalite is accompanied by a volume increase of 13.6 per cent and quartz to tridymite of 16.7 per cent. From this fact one sees that even after a maximum development of cristobalite, when the tridymite begins to form, there will be an increase in volume. Holding the temperature in burning at a maximum for several weeks instead of two or three days would probably increase the development of cristobalite and produce some tridymite.

The Manufacture of Silica Brick

All processes of manufacture of silica brick are fundamentally the same, differing only in the execution of certain steps in the process. In general, it is a grinding, mixing, forming, drying and burning process. The older methods included semi-drying, re-pressing and then complete drying. Recently, however, by working the batch stiffer, re-pressing has been eliminated. The consistency is such that the brick retain their shapes after being dumped from the molds and they can be dried completely without re-pressing.

The method of winning raw material will depend to a large extent upon its occurrence. In places where the quartzite occurs as a talus it is only necessary to break the pieces to a size which can be handled and to transport them to the plant. Where the raw quartzite is quarried, the usual quarrying methods are used and the material loaded onto cars. Some plants are located a considerable distance from the quarry, and in this case shipment is made in freight cars. At the plant it is dumped from a trestle either directly into the jaw crusher, if it is to be used at once, or into a storage bin and then into the crusher. Great precaution is exercised in the selection of this raw material. The crusher used is the ordinary jaw crusher; it crushes the raw quartzite to pieces about two cubic inches in size. From here it is elevated, dropped into a steel hopper over a wet pan and is ready to feed into the pan for further grinding and mixing with lime. The wet pans are

7 to 9 feet in diameter and operate periodically, one charge being enough for 150 to 300 standard brick. Sufficient water is added to give the mass molding qualities, and in this water milk of lime is suspended to such a concentration as will add 2 per cent lime to the batch. The purpose of the lime addition is to give the brick a bond in the burned state. A greater amount of lime decreases the resistance of the brick to abrasion, and less lime makes it friable and crumbly to the fingers. High lime also decreases the refractoriness of the finished brick. The degree of fineness will depend upon the time of grinding. This will depend upon whether the batch is to be used in special shape or standard brick work. Because of the difficult shapes made, the special shape batch must be ground finer or longer than the standard brick batch. At the previously mentioned plant the time of one grinding is approximately 15 minutes for standard brick. This may be increased to 25 or 30 for special shapes.

The charge is removed from the wet pan by an automatic plow, which is lowered into the pan, scoops up the material and throws it over the side. Here it is either caught in a cart conveyor, or thrown onto a molding table or belt conveyor. In one plant the batch is elevated to large steel tanks where it comes down directly over the molding tables. Other plants transport the wet batch in dump cars to the floors on which the molding is to be done. At one plant part of it is trucked to the molding room after being elevated to a bin, and the rest is elevated and conveyed to the second floor where special shapes are produced. Here the shapes are made and dried on the hot floor. Molding the ware is done by hand. The batch is worked stiff, rammed into steel molds with pneumatic hammers or by hand, then inverted onto a pallet and the outside molds stripped off leaving the brick on the pallet. From two to 10 brick are made in one mold. The molds are made of steel and can easily be taken apart and put together. The brick are then placed on cars and pushed into drying tunnels through which they travel progressively. It takes from three to five days for the brick to pass through such a tunnel and during this time drying takes place. The tunnels are heated in various ways. A common method is to use the waste heat from

cooling kilns. Air is drawn through the kiln, being cooled, passed down through large flues up into one end of the tunnel, through the tunnel and exhausted at the other end. Another method is to use the waste steam from a steam engine during working hours and live steam at night. Special shapes are dried on drying floors instead of the tunnels, owing to the variety of shapes. From here they are wheeled to the kiln.

The brick should leave the dryer completely dried and very sound. They are then taken by cars to the kiln and set for burning. The kilns are round or rectangular down-draft kilns. Soft coal is used for fuel. The burning to a maximum should be done very slowly, as rapid burning produces a shattering of the silicious material, and the development of cracks and fissures in the quartzite. An abnormal expansion which would simulate a true expansion could occur here by rapid heating, but the bricks would fail in any abrasive tests to which they might be subjected. Burning is continued slowly for seven or eight days, then the temperature held for 24 to 48 hours. Then the fires are drawn and the fireplaces sealed for 48 hours. After that one or two and finally all are opened. The whole cooling process requires eight to 10 days. The cooling is just as important and requires as much or more care in producing a ware free from strains as the burning. From the kiln the bricks are taken either directly to the shipping platform or to the warehouse. Warehouses or storage rooms should be completely covered, free from water, and the brick fully protected from the action of the weather.

Tests of Silica Brick

Of primary importance in the physical properties of silica brick are its resistance to abrasion, cross-breaking strength, strength of compression, its thermal conductivity, refractoriness, load-carrying capacity at high temperature, and finally the amount of its permanent expansion after the first burning.

Resistance to abrasion can be determined by a modified sand-blast or rattler test. The rattler test as applied to paving brick has been especially successful. The rattler consists of a 14-sided steel barrel in which 10 standard brick and 300 pounds of spherical shot are placed and the whole rotated 1800 revolu-

tions. The loss in weight of the brick is the criterion of the test. At the present time all the large cities and municipalities buy brick based entirely on their action in the rattler. A similar standardized test on fire brick required of the seller by the purchaser would certainly help in determining those brick which showed high resistance to abrasion.

Cross-breaking and crushing-strength tests have been used by various investigators in following the change in strength in a brick after different processes that the brick have been put through. In the cross-breaking test the brick are laid edgewise over a span of 6 inches and loaded at the center. The crushing strength is determined on a flat piece bedded firmly in a crushing-strength machine. McDowell gives values for a regular grind brick of one burn of 700 to 900 pounds per square inch modulus of rupture; and crushing strength 2100 to 2700 pounds per square inch. For an Illinois fire brick, Havard gives the crushing strength on the side as 2345 pounds per square inch; on the edge, 1546 pounds per square inch, and on the end, 2119 pounds per square inch.

Load-Carrying Capacity at High Temperature

Silica brick or any refractory brick which bear heavy loads at high temperatures should have high compressive strength at these temperatures. For fireclay brick such a test has been accurately worked out by Bleininger and Brown and will be described later. Silica brick tested by Brown in the same way showed excellent resisting qualities. A sample brick standing on end, subjected to a load of 50 pounds per square inch, held at 2460 degrees Fahr. for one hour, showed no change. In another test the brick was subjected to a load of 50 pounds per square inch at 2680 degrees Fahr. without being affected. Other specifications than those used for firebrick could be made for silica brick. Such tests would be useful in bringing out the relative value of the various kinds of brick and in showing how these brick would act in a structure where they must carry a high load at high temperatures.

The thermal conductivity of silica brick is very low. In some structures this is an advantage, in others a decided disad-

vantage. Magnesite brick are better heat conductors. For certain purposes, as in coke oven work, any treatment which will increase the conductivity of silica brick would be valuable. In other operations the conductivity should be small, and those brick having a low conductivity should be used. Brown showed that silica brick had 8.99 per cent higher conductivity than clay brick. The state of division of material in the brick, the number of pores, the burning treatment, and the composition all influence the conductivity.

Silica brick on heating have a linear expansion due to the increase in temperature. Besides this increase in expansion, however, there is a permanent expansion due to a change in state in the raw material. This was previously discussed under the properties of raw quartzite. The linear expansion is entirely distinct from the permanent expansion and should be considered in any application of silica brick. It varies from 3.0 to 4.5 per cent. Bleininger showed that permanent expansion increases directly with the temperature; it does not coincide with the development of cristobalite. He suggests cones 18 to 20 as the minimum burning temperature for silica brick. It would seem that the complete development of tridymite in the brick as the stable phase is impractical for the manufacturer of silica brick. However, whatever this permanent expansion is, it should be known and allowance made for it when the brick are placed in a furnace wall.

The rate of heating has a great influence on the structure of the brick. Rapid heating will produce abnormal expansion, but the brick will not be sound. Disintegration of the body results and the resisting quality of the brick will be reduced. This is directly connected with the spalling tendency of a brick. Spalling is a breaking down of the brick structure due to too rapid changes of temperature. Although the only external evidence of spalling is the splitting off of pieces, still there is considerable effect on the internal structure. McDowell showed such a result by heating the brick up slowly, then cooling rapidly, but not so rapidly as to cause parts of the outside to break off. The cross-breaking strength on such treatment fell off consid-

erably. Brick before being used should be tested for this property and those brick selected for use which offer the most resistance to spalling.

The Uses of Silica Brick

Because of its refractoriness and absence of the tendency to shrink, silica brick are, wherever possible, displacing high grade fire brick. They cannot be used in places of sudden heating and cooling, because too rapid changes of temperature will weaken the material. In open hearths, coke ovens, acid converters, crucible furnaces and heating furnaces, silica brick have found wide uses. In basic open-hearth work, silica brick are used above the slag line and for the roof. Due to the lack of shrinkage it is possible to construct roof and crowns of silica brick which will keep tight and also possess refractoriness. Kelley speaks of their use in steel converters as a first lining over which a 3-inch course of ganister is placed. This ganister is very refractory; the lining has given as high as 18 months service. Silica brick have replaced clay brick in the crucible steel melting furnaces so favorably that linings which formerly lasted four to six months are now used for as high as 40 months and have an average life of 14 to 18 months. He also states that silica brick are used exclusively in electric furnaces except where magnesia brick are used on account of the basic character of the slag. He considers the temperature in this furnace higher than in any other operation and the refractoriness required of the lining greater.

In the open hearths, silica brick are being used wherever possible. In the basic process, magnesia brick are used for the linings in contact with slag and metal, but above the slag line and in the roof silica brick are used to the greatest extent. In the basic process the bottoms and part of the sides are made of magnesite brick and fused magnesite; between the top of the magnesite and the bottom of the silica a buffer layer of refractory chrome brick is used. In the acid type, silica brick are used for the bottom and covered with fritted sand.

The acid bessemer converter uses silica lining in silica brick, but in the basic process the complete lining is of magnesite and magnesite brick. With the decreasing use of the bessemer and

increasing use of the open hearth, the demand for silica brick will naturally show an increase.

Basic and Neutral Refractories

The most common materials used in basic and neutral refractories are the crystalline or amorphous mineral magnesite, and dolomite. Other magnesian minerals have been used alone and in combination with fire clays as a heat resister for years. The various forms of asbestos, serpentines, steatites and soapstones have been used. The melting points of both lime and magnesia are very high; Havard gives values for magnesia as high as 4532 degrees Fahr. where it forms a viscous mass. Rankin and Wright estimate the melting point of lime at 4660 degrees Fahr.

The use of lime alone as a refractory has not been successful, partly because of its affinity for moisture and because of the formation of calcium salts of iron. Judging from its refractoriness alone, it could make as equally valuable a refractory as the magnesia.

Magnesite used in the manufacture of magnesite brick is produced largely in Europe. There are two grades, the amorphous, produced in Greece and Norway, and the crystalline from Styria. Deposits in America are just beginning to be worked. California has notable deposits. The United States Geological Survey reports that in 1914, four per cent of the magnesite used was domestic production, 93 per cent was imported from Austria and the remainder came from Greece. Since the war, domestic consumption has increased. On the whole, however, it is extremely doubtful whether the American deposits can supply the demand as long as the foreign deposits are available, both because of the nature of the material and because of the small size of the deposits so far located. Youngman gives the following analyses:

	Crystalline from Austro-Hungary Per cent	White variety from Styria Per cent.
Silica	2.75	2.5
Alumina	0.5	0.24
Iron oxide	7.0	1.0
Lime	2.5	2.25
Magnesia	87.0	93.0
Alkalies	0.75	1.0

Non-crystalline deposits in Greece, and magnesite quarries of Austria, contain magnesite in large quantities, the Grecian is used more for the sorrel cement industry and the Austrian for the refractory industry. The massive variety has a whitish yellow color, while the crystalline is blue-gray to drab and contains pieces of slate.

The Austrian deposit is worked in benches of 50 feet in height. The rock is blasted out, broken down and sorted. The quarries are above the level of the plant so that the material can be loaded on the cars and dropped by gravity to the mill.

Magnesite is either caustic or calcine burned, or dead burned, depending upon how it is to be used. The caustic burn corresponds to the treatment of limestone in the production of quick lime. The raw magnesite is burned to from 1850 to 2000 degrees Fahr., in which state it retains about 3.0 per cent of its CO_2 content. This leaves the mass active and capable of recombining with various substances.

In the dead burned variety, the magnesite is burned to a sinter. All the CO_2 is removed and the substance largely loses its power to recombine with other substances. It is nonhygroscopic and has all shrinkage removed; it becomes chemically inert and in this form acts as a refractory of good quality. It is burned to a temperature of 3260 degrees Fahr. As the Austrian magnesite contains 2.5 per cent iron oxide, it will burn to a dense mass at a lower temperature than the Grecian material and still be sufficiently refractory for commercial purposes.

Magnesite brick are composed of 15 to 25 per cent low calcined magnesite, 2 to 3 per cent iron oxide added to increase the bond, and dead burned magnesite. About 50 per cent of the dead burned magnesite imported to this country is used directly in the grain form to sinter on to the bottom of open hearths and used as a cementing filler in other places, as in the basic bessemer converter.

Iron oxide is added with the original raw batch of calcine and is added to the final mix in this form. These two ingredients, calcined magnesite and dead burned magnesite, are mixed together. Sometimes a binder is added, such as various tars, alkalies, etc., at the expense of the caustic

magnesite. However, the common practice is to use no bond. The brick are molded by hand or pressed by steam, dried and burned. In order to provide a method of burning, compartments are built of silica brick; in these compartments the brick can be arranged in two layers or two brick on end, so that the most weight one brick bears is that of the brick on top of it. This is necessary because of the weak bond of the raw brick. The temperature of burning varies from 2160 to 3000 degrees Fahr. The increase in temperature must be slow to prevent cracking.

Properties of Magnesite Brick

The tests will not differ essentially from those on silica brick. The basic refractory, however, will not show the strength shown by the silica brick. It is ordinarily of high refractoriness, although in some cases it has been known to fail at low temperatures. The brick has a great tendency to spall and crumble with sudden temperature changes and at extremely high heat. The exact action will depend upon the chemical and physical properties of the raw material, but to a large extent also on the method of manufacturing, grinding, tempering, drying and especially the burning. Specifications have not yet been outlined for all tests on the physical resistivity of magnesite brick. They will undoubtedly form part of the complete specifications on refractories which are being prepared by the American Society for Testing Materials. Any improvement in batch, or method of manufacture which will decrease the tendency to spall will be a great step forward in its practical application to the industries.

Dolomite is used to some extent as a lining in place of magnesite. It is a magnesium carbonate in which part of the magnesia has been replaced by calcium. It can be obtained cheaper than the magnesite and for that reason has somewhat replaced it, but it is not satisfactory when made into brick, as it tends to crack at high temperature. It has, however, found considerable use as a lining.

Fire Clay Brick and Shapes

With the improvements in the manufacture of silica brick which have greatly extended their use, the fire brick

have gradually given place to them in certain metallurgical processes. Magnesite and bauxite brick, too, have decreased the use of fire brick because of their better adaptability, due to an increased refractoriness, or a more favorable chemical nature. There are, however, numerous operations in metallurgical and high temperature work where fire brick and fire clay shapes will continue to be used extensively.

Clay is an alteration or decomposition product of various minerals which have separated from igneous solution. Its history on earth may have been so varied that it has lost all trace of its original character, but the origin of all clays is traceable to this weathering action on such minerals. Natural agencies have eroded, transported, mixed and re-deposited the original decomposition product and have formed beds and deposits of clays. Further action, such as plant life, metamorphism and percolating underground waters have again altered the original deposit. Thus, in the earth we have all degrees of this process from the original decomposition product called residual clays, through the various recently developed beds of sedimentary clays containing impurities of all sorts, to the metamorphosed re-purified beds which have the same chemical composition as the original decomposition product and which form the greatest part of our commercial fire clay deposits. The impurities present are either from the original undecomposed rock or another product of the decomposition, from admixed material during the process of transportation of the clay, or substances carried into the clay body later by action of the water. Such impurities decrease the refractoriness of the clay. They have numerous other bad effects which make the clay unfit for other purposes, but their general effect on refractoriness is the point in which we are interested.

Such relatively pure clays are high in alumina; pure clay itself contains 46.4 per cent silica, 39.7 per cent alumina and 13.9 per cent water. Fire clays differ in the degree of their plasticity, or their ability to take up water to form a plastic mass. According to this physical property, fire clays are divided into plastic and non-plastic. The non-plastic, or flint clays, are those which develop low plasticity on treatment with water, and have a very high melting point. Plastic fire clays are those

relatively pure clays which have a distinct plasticity on treatment with water and which have a high melting or softening point. Sufficient alumina should be present in the fire clay to combine with the silica to form Al_2O_3 $2SiO_2$. Any excess of silica over this amount will act as a flux in the clay. It may be present combined with an oxide forming a silicate, but in this case the silicate acts on the clay to reduce its refractoriness. The plastic clays are generally of lower refractoriness than the flint clays and when used in the production of fire brick or shapes are used merely as a bond.

Purdy states that the fusion point of a clay is influenced by the following factors:

1.—Manner of combination of the constituents in the clay.
2.—Size of grains of the several mineral constituents.
3.—Amount, form and character of the volatile constituents do not directly affect the reactions, but the difference in the physical structure of the clay and stability of the non-volatilized compounds caused by the expulsion of these substances affects the manner of fusion.
4.—Absorbed salts.
5.—Precipitated materials present.

These conditions so influence the refractoriness of the clay that usually one cannot infer its fusing point from the chemical analysis of the clay alone. The only safe test is a test of the clay itself. Small cones are made of the unknown clay and are heated at a constant rate until they bend over or ball up. The temperature at which this action occurs is taken as the fusing point.

Most fire clays being mined at present occur in the coal measures, usually underlying a coal seam. Large deposits are found in Pennsylvania, New Jersey, Ohio, Kentucky, Missouri and Illinois. The higher grades of plastic clays are found in New Jersey and Pennsylvania, the flint clays in Pennsylvania, Ohio, Kentucky and Missouri. The clay found underlying coal is usually pure because of the action of the ancient plant life (which now makes up the coal beds) on the salts in the clay. These plants, in search of food, removed the alkalies and salts in the clay and left it free from impurities. Fire clays, both plastic and flint, are usually mined by operations quite similar

to those employed in coal mining. The vein is worked in rooms; the clay is blasted down, loaded on cars and elevated to the surface. Because of the lack of cleavage in the vein, machinery has not been used in pulling the clay down.

How Fire Clay Refractories Are Made

Fire clay bricks and shapes are made up of the two materials, flint clay and plastic clay, and a third, grog. Grog is a clay from which all shrinkage has been removed by burning. It consists of either flint clay, calcined, or old fire brick bats and shapes, ground up to be added to the batch. These three materials, flint clay, plastic clay and grog, are worked together through the preparing plant and mixed in a wet pan. Of the three constituents the plastic clay is usually the least refractory and weakest. In some cases grog, coming originally from a poor quality brick, will fail before the plastic clay, but this can be prevented by completely eliminating every kind of grog except calcined flint clay, and adding only the best flint clay as calcine. It is necessary, however, to add some plastic clay. Something is needed to bond thoroughly the flint clay and the calcine and to give the brick a sound, firm structure. This is accomplished by the plastic clay.

The proportioning of the mix will depend upon the use to which the brick or shape is to be put and where it is to be located in any given furnace. Some brick must resist high temperatures under load; others are subject to enormous abrasive action; some must resist rapid heating and cooling; and still others must resist chemical action. These considerations will influence, if not finally determine, the exact proportions of the three components which make up the brick or shapes. As an example, we may consider the action occurring at different places in a cupola or blast furnace. Near the top of the shaft the fire clay sides are subject to enormous abrasive action; the raw materials fed in at the top gradually scrape their way toward the bottom. Up to the point where melting first begins and a pasty mass is produced, the lining does not need to withstand a particularly high temperature, but it must be resistant to abrasion. A dense, hard material, which may or may not be highly refractory, and which usually is not, should

be used. In this brick or block, the amount of plastic clay will be greater than the other constituents, because the plastic clay, reinforced with some flint and calcined clay, will give a dense, hard struction on burning. Farther down the cupola the proportioning of the mass will be governed by resistance to slag action, to high temperature and to high temperature under load conditions. Its requirements vary from low refractoriness with abrasive strength at the top, to extremely high refractoriness at the hearth and bosh. For such work in blast furnaces, hearth and bosh, inwall and top brick are made. For the hearth and bosh, the brick are made of maximum refractoriness; for the inwall they are made for refractoriness and strength in abrasion; and for the top, the brick are of a dense and tough structure. In a similar way with other operations, the proportioning of the material will depend upon the operation and action which the brick must resist.

After the three ingredients are thoroughly pugged together, the plastic mass, commonly called the pug, is aged, to produce a homogeneous material with a uniform water content which will allow a uniform shrinkage. Molding and drying is quite similar to the methods used in the manufacture of silica brick. The temperature of burning is from 2550 to 2650 degrees Fahr. Coal or producer gas is used. After reaching the maximum temperature the firing is stopped, the kiln is sealed up for three or four days and the brick allowed to anneal. Cooling to normal temperature takes three or four more days. The brick are then removed, stored or shipped.

Determining Properties of Brick by Test

Before fire brick is put into use a sample brick should be subjected to certain tests which reproduce as nearly as possible the action which the brick will be called upon to resist while in a structure. Those brick which show up best in these tests are the ones which will naturally be used. Such tests are tests for compression, cross-breaking, strength, spalling, resistance to abrasion, action under load at high temperature, slag, refractoriness, thermal conductivity, coefficient of expansion, etc. It is the work of the American Society for Testing Materials to study various aspects of the problem and to specify those tests which

will show in a practicable manner the future action of any given material in its application to the work for which it was intended.

Nesbit and Bell in *Transactions* of the American Society for Testing Materials, have worked out a series of tests for fire bricks which can be conducted at any plant at a small expense and with very desirable results. They use tests for impact, abrasion, spalling, slagging, compression, expansion and contraction. Two other important properties which should be tested by a plant are the fusibility and load resisting qualities.

The impact test is used to test the quality of brick to resist impact. A brick to be tested is heated to 500 degrees Fahr. and held for three hours; it is then placed on a steel block so that a ball, dropping, will hit the exact center of the up-ended brick. The ball, 2½ inches in diameter, is dropped from heights increasing by 2 inches until the brick is fractured. The distance in inches of the last drop is the result of the test. The results show that a brick at 500 degrees Fahr. is 20 per cent weaker and at 1000 degrees Fahr is 40 per cent weaker than the same brick at 68 degrees Fahr.

The abrasion test is conducted with a carborundum wheel to show the resistance to abrasion, when the brick is heated to 500 and 2460 degrees Fahr. The wheel is a vertical carborundum wheel with 2-inch face, 18-inch diameter, and is mounted on a stand. The brick is placed on a plate in front of the wheel; the surface of the plate is 1¼ inches below the center of the wheel so that the center of a 2½-inch brick will be at the center of the wheel. Pressure on the brick is equal to 10 pounds per square inch against the surface of the wheel. The brick is ground to a thickness of 2.35 inches and the ends ground so that the wheel in the test cuts through this exact thickness. The depth of the preliminary cut is then taken, the brick heated up slowly to 2460 degrees Fahr. in six hours and held there for three more hours. It is then removed, placed flat on the plate in front of the wheel and held in contact for five minutes. The brick is then returned to the furnace, reheated for one hour and the test repeated on the opposite end. The result is the difference in depth between the pre-

liminary and final cut in inches. The work of Nesbit and Bell brought out the fact that brick had different resistances to abrasion at opposite ends.

In the spalling test, the furnace is first heated to 2460 degrees Fahr. and held at this temperature for one hour. The brick are dried at 210 degrees Fahr. for five hours, weighed and placed in the doorway of the furnace for one hour. They are then removed, plunged into two gallons of water at 68 degrees Fahr. to a depth of 4 inches and held for three minutes, removed and allowed to dry for three minutes. The operation is repeated 10 times. The brick are then dried at 212 degrees Fahr. for five hours, all loose particles removed and the brick weighed. The loss in weight represents the tendency to spall.

Conducting Test on Slagging

From a number of experiments Nesbit and Bell came to the result that the best method of testing the brick for slagging was by drilling holes partially through the brick and filling them with the slag to which they would probably be exposed in use. The length of the brick is bisected by a line, and in the center of each half a hole 2½ inches in diameter and ½-inch deep is drilled. The brick are placed level in a cold furnace and heated to 2460 degrees Fahr. as before. At this temperature 35 grams of standard blast furnace slag are placed in one cavity, and 35 grams of standard heating furnace slag in the other. The brick are held at this temperature for two hours after the slag is added. At the end of that time the furnace is cooled, the bricks are sawed longitudinally directly through the center of the cavity. The area of penetration is determined and from this is subtracted the original cross section. The difference is a measure of the action of the brick towards the slag.

Nesbit and Bell's tests for compression was by measuring the penetration of a steel sphere under a given load. The brick rests upon a solid foundation; directly over the brick is a channel iron, fulcrumed at one end, and with weights applied at the other, the total weight being 1600 pounds. The brick is heated as before, removed and placed flat beneath the bar. A spherical impression in the bar marks the position of the ball.

The ball is then put in contact with the center of the brick and the depression in the bar. Weight is applied immediately and maintained for five minutes. The depth of the impression is a measure of the compressive strength of the brick at high temperature.

In determining expansion and contraction, the brick is heated as in the compression test and the length measured before and after heating. The result in inches per foot gives the normal expansion and contraction of the piece.

A method of determining the compressive strength at high temperature has been worked out by Bleininger and Brown. Their work in this connection is exhaustive; it not only brings about a measure of load carrying capacity of the brick at high temperature, but it also indicates how the brick fails, what compounds are the first to give way and how a better body could be developed.

Depending upon the amount of deformation at 2460 degrees Fahr. and 50 pounds pressure per square inch when held for one hour, they have proposed the following classification:

1 (*A*).—Those clay refractories which do not show a deformation below cone 31 or 3182 degrees Fahr., and when tested for load-carrying capacity will not show a deformation of more than 1 inch in 9 inches. Later specifications change this to ½-inch.

1 (*B*).—Those refractories which withstand a temperature up to cone 31, 3182 degrees Fahr. and in load-carrying capacities will not show a deformation more than 1 inch in 9 inches under a load of 30 pounds pressure per square inch.

No. 2 Refractories.—Those which will not soften below cone 28, or 3074 degrees Fahr. They should be able to withstand a load of 25 pounds per square inch at 2380 degrees Fahr. without contraction of over 1 inch in 9 inches.

Importance of Practical Tests

Similar tests made on every shipment of brick or shapes used in a structure will determine to a large extent their value for a particular operation. Those brick should be used which show the greatest resistance to the particular action to which they will be subjected when in use. Other tests may be devised

for special cases; any arrangement which will indicate in a short time how a certain brick will act in a certain place will aid in the selection of the right bricks for that place. If all operators would conduct such tests it would undoubtedly bring to them a more thorough knowledge of the refractory materials; it would afford common grounds for discussion between the consumer and the producer, and would undoubtedly bring about a wiser and more profitable use of such raw materials as we have available. The manufacturer is using the best material he can find in the production of a ware, and it is the province of the consumer to use that ware in a way which will give him the greatest return on the money invested. A thorough knowledge of the material will help the consumer of refractories to produce a better grade of metal at a less cost.

Other refractories are bauxite brick, chrome brick, materials containing carbon as the chief refractory, carbon-silicon compounds, cement, mortars, the metal refractories, and many others. A discussion of the use and preparation of all these different substances would, however, lead too far afield. Of most importance to the iron worker is probably the chrome brick, which, because of its great refractoriness, can be used in the basic open hearth as a buffer lining between the magnesite and silica. Chromite is found as a chrome iron ore, a dark, metallic, splendent mineral of extreme hardness, containing 40 to 50 per cent chromic oxide. Although chromic oxide itself is extremely refractory, the chromite ore mixed with iron oxide, alumina and silica, is much less refractory. It is, however, sufficiently resistant to withstand the temperatures in the open hearth and its neutral nature makes it very resistant to the slags formed in the melting. It is used to cover ports as a liner between the magnesite bottom and the clay brick foundation of the open hearth.

The greatest deposits and practically the only ones which are being worked at the present time are found in Greece. The material occurs in Asia Minor, in Cuba, Styria, in the Urals, in Pennsylvania, Massachusetts, Maryland, Georgia, New York, North Carolina, Oregon, Virginia and California. It is first crushed and picked by hand, then ground in dry or wet pans, mixed with a binder which may be fire clay, magnesia, lime,

dolomite, or one of several others. Only enough water to give the body a bonding power is added. The burning is similar to magnesite brick. Two bricks are placed together on ends in compartments made with silica brick.

Various reports are given as to the strength and action of chrome brick while in operation. Havard reports that they are unreliable at a temperature above 2730 degrees Fahr., and that at 3270 degrees Fahr they become soft and crumbly. American practice, however, is to use them where a neutral lining is desired.

Fire Protection in Industrial Plants

By C. W. Johnson, East Pittsburgh, Pa.

(Contributed to the Joint Program, Sept. 24, by the American Institute of Metals.)

The danger of fire is always present. It can be likened to a crafty, sleepless enemy, constantly watching and waiting for an indication of weakness in our defense so that it may strike when and where we expect it least. In considering the subject of fire protection it is necessary that we always look upon it in this light. There is no such thing as planning and arranging for certain protection and then going about our other business and forgetting the danger of fire. It is only by "eternal vigilance" that fires can be avoided, and it is only by the most complete preparedness that they can be promptly extinguished.

The whole theory of fire protection is expressed in the preceding paragraph; the trouble with us is that we are not sufficiently impressed with what it means. In many plants of small size there are frequently times when weeks, or even months, may pass without even a small fire, and vigilance and precautions accordingly lapse. In an extremely large plant, such as the writer is connected with, small fires occur from time to time, and for that reason it is more easy to retain the necessary alertness. However, even under such conditions, after the repeated experience of having these small fires quickly extinguished, the majority of the responsible heads in the plant are apt to assume, as a matter of course, that those whose special business it is will always attend to their duty and prevent any serious conflagration. In this way a still greater menace is introduced in the carelessness which the factory heads develop with regard to the danger of fires. It therefore becomes necessary that there be some positive, driving force, ever present, to constantly, and at all times, hammer in the essentials of vigilance and preparedness.

The subject of fire protection may be sub-divided into: first, the elimination of the causes of fires; second, the pro-

tection against the spreading of fires when once started; and, third, the extinguishing of fires.

An impressive fact surrounding the causes of fires is that in almost every case they are caused by negligence and carelessness of the most obvious kind, and that they can be prevented by observing the most simple expedients and watchfulness. If we can but realize the truth of this statement and take it to heart properly, we will have taken the first step toward fire prevention. But someone must do this: and do it every day; and do it intelligently—not merely as a matter of form—and if the person is absent whose duty it is to attend to such things, then there must be some positive plan by which someone else will be present and will do the things that must be done. This is an attempt at saying what is meant by "eternal vigilance."

With regard to the other two points in fire protection, volumes could be written. It is not intended to have this paper go into details as to how a plant should be constructed or how the fire protection should be arranged physically, but rather to outline the underlying principles which must be thoroughly absorbed and believed in before any plant manager is competent to lay out or direct the fire protection of a plant. The writer believes that the physical details and principles of fire protection can best be obtained through some association of insurance companies, such as the Associated Factory Mutual Fire Insurance Companies, as the officers and engineers of these associations have made this their life study. To anyone who is not now insured through one of these associations and who does not have the benefit of their advice and assistance, the writer recommends a study of their literature on the subject: A large number of booklets and manuals published by the Associated Factory Mutual Fire Insurance Companies are listed in the appendix accompanying this paper. These will be found to be of intense interest and of the most practical nature.

The need for an advisory influence such as is provided by an association is made very evident by the mental attitude of factory managers towards suggestions which their engineers are constantly making. These suggestions are invari-

ably sound and sensible, are based on fact and actual experience, are practical and reasonable, and always result, when properly carried out, in reducing fire risk. Yet almost invariably such suggestions are opposed on the score of the expense involved. The lesson to be drawn from this is that any man's mental attitude needs careful training and adjustment before he is competent to be trusted with the fire protection in a plant.

One extremely cold, windy day last February a large plant in the Pittsburgh district was almost completely destroyed in about two hours' time. The protection against fire in this plant had been considered to be very nearly ideal, but it so happened that the fire started on Saturday afternoon when very few men were present in the plant. It was so extremely cold that certain of the water connections were turned off, and changes were being made in the power plant and in the fire pumps, which resulted in low steam pressure. An electric fire pump had been installed which had not been connected to the lines. The combination of all these conditions was fatal.

The natural result of such a fire in a well managed plant was to greatly alarm the responsible heads of the plant with which the writer is connected. As a result a very rigid and searching inspection was made. The results of this inspection were very gratifying and the first feeling was one of satisfaction and self-congratulation. After a few days, however, in discussing the matter a second inspection was suggested, which was to be made by men to whom the subject of fire protection was new and who were told to insist on having every point proven. In the main the results of this investigation were satisfactory, although quite a number of weaknesses were found which had not previously been brought to light. Later on, a third and entirely independent detailed study was made which developed a large number of weaknesses, such as the manner in which dangerous oils, paints, varnishes and highly combustible and explosive materials were kept in the workshops. It was found that sprinklers had not been installed in a number of isolated locations where there was a pronounced danger of fire; certain details

of fire fighting equipment needed improvement; and, lastly, the routes of watchmen were entirely relaid out and reorganized, so as to insure all points of the plant being covered thoroughly at stated intervals, with the watchmen on their beats meeting each other and their routes crossing at stated points, with telephone communication to the company's police headquarters, and with a desk sergeant who at all times during the nights and holidays has an exact check on the location and activity of these men. Another fact was brought out, which has an important bearing on the matter and is of interest to everyone, and that is, that at conferences in the "front office" the superintendent in charge of buildings and grounds would be delegated to carry out a certain policy of daily routine inspection of fire hazards, chemical engines, fire hose, hydrants, sprinkler valves, etc.; the superintendent in charge would then in the regular course of his duties lay out with the fire marshal the details of carrying out these inspections; and the fire marshal would then train the individual inspectors and allot them their duties—the point being that in the end, the actual work and responsibility was carried by the inspectors, who were in some cases day laborers at ordinary laborers' wages, and there was no positive check or provision made to see that they were actually on the job every day. In other words, any one or two of these men might for a period of several hours be absent from his duties without anyone's knowledge, and this short time is all that our enemy, fire, requires to get in his work. This is simply another way of driving home the thought of "eternal vigilance."

As a matter of general information, a set of instructions for inspection is appended hereto, which may be of interest as indicating the manner in which one company has gone at the question.

One of the greatest safeguards in the plant referred to is the resident fire department, consisting of 32 men, in charge of a thoroughly competent captain and of lieutenants —who are located in a dormitory adjoining the works. These men are thoroughly trained, respond to all fire alarms, whether they are at work in the plant or asleep in the dormi-

tory. They also respond to borough fires in the nearby district and succeed in putting out fires, even when they have had a good start, within a few minutes after the alarm is turned in. In a small plant, such a plan is not so feasible as in a large one, but it is just as necessary, because when a fire does start, trained, expert fire fighters, right on the job, can put it out quickly; whereas, inexperienced men, who are untrained, are usually helpless.

To sum up the matter: We must do all we can not to let fires start. If they do start, we must have positive arrangements so that the fact will be known and announced at once. When this fact is announced, trained men with proper equipment must be gotten to the scene without loss of time, no matter whether the fire occurs at four o'clock on Sunday morning, or during working hours, when all the employes are available for assistance.

But, most important of all, the writer has attempted to impress the principle that it is necessary for thinking, analytical managers to devote much time and thought and planning to the question of fire protection, and to keep on thinking and checking and planning and watching, and that they never can come to a point where it is safe to forget this risk and depend on a system which they have provided.

Appendix

Associated Factory Mutual Publications

Pamphlets

1.—Anchorage of Roofs.
2.—Approved Electrical Fittings.
3.—Approved Fire Protection Appliances.
4.—Beltway Fires.
5.—Carbon Tetrachloride as a Cleaning and Solvent Agent.
6.—Centrifugal Fire Pumps—Specifications, and Rules for Electrical Driving.
7.—Cotton Conveying Systems from Bale to Opener Room.
8.—Dry-Pipe Systems of Automatic Sprinklers—Rules.
9.—Electric Light and Power Equipment—Rules.
10.—Fire Hose, Play Pipes and Hose Houses—Rules.
11.—Fire Pump Protection for City Risks (Paterson Fire).
12.—Fires in Cotton Mills.
13.—Fuel Oil Installations for Furnaces and Engines.
14.—Gravity Tanks and Towers—Specifications.

15.—Installations for Handling Gasoline and Similar Oils.
16.—Installing Sprinkler Equipments—Rules.
17.—Laying Cast Iron Water Pipes in Factory Yards—Rules.
18.—Notes and Suggestions on Fire Pumps.
19.—Prevention of Large Loss in a Mutual Mill.
20.—Rotary and Centrifugal Fire Pumps—Specifications, and Rules for Electrical Driving.
21.—Sawdust as an Extinguisher of Fires in Moderate Sized Tanks of Lacquer, Paint, etc.
22.—Sprinkler Protection in Picker Trunks, Dryers, etc.
23.—Steam Pump Governors and Auxiliary Pumps—Specifications.
24.—Underwriter Steam Fire Pumps—Specifications.
25.—Valves, Indicator Posts and Hydrants—Specifications.
26.—Water-tight Floors of Mill Construction.
40.—Concrete Storehouse.
41.—Fire Doors.
42.—Humidity for Preventing Fires in Rubber Factories.
43.—Mill Watchman.
44.—Edison Phonograph Works, Burning of.
45.—Dry Rot in Factory Timbers.
46.—Salem Conflagration.
47.—Fire Hazards in Charcoal.
48.—Mill Fire Brigades.
49.—Fire Protection of Pyroxylin Plastics (Celluloid).

Leaflets

27.—Directions for Use of Red Tags on Closed Valves.
28.—Fire Brigades Inside Mill.
29.—Mill Fire Brigade Data and Sheets.
30.—Rotary Fire Pumps—Directions for Starting.
31.—Steam Fire Pumps—Directions for Starting.
32.—Weekly Inspection of Fire Protective Apparatus. A Suggestive Form of Blank.
33.—When Putting in Fire Protection—Things to be Considered.
34.—Failure of Public Water Supplies.
35.—Gage Connection for Use in Testing Main Controlling Valves.
36.—Longleaf Pine Factory Timber.

Rules for Prevention of Fires

Water Supply

There are three separate sources of water supply available in case of fire: (1) Pennsylvania Water Company; (2) Ardmore Dam; (3) Turtle Creek, and under normal conditions these would be made use of in the order named.

Sprinklers

All risers should be examined daily to see that main valve is open, drain valve closed and both properly sealed.

Wet System. (To be tested yearly.)

Put gage on riser and open drain valve. If gage drops, say 5 pounds remaining stationary at this point, it is evidence that water is on the line.

A further test should be made as follows:

Close main valve, allow sprinkler line to drain to zero on gage, close drain and open main valve. If pressure again builds up to normal it is evidence that water is on the line.

Dry System. (To be tested yearly.)

See if air gage stands at 45 pounds and water gage at 110 pounds. Open drain and allow air gage to drop, say 5 pounds to see if air is on the line and gage not sticking. Close drain, open air valve and build up air to 45 pounds on gage.

Open valve to water gage and if water flows it is evidence that water is on the line.

Indicator Posts.

All indicator posts should be inspected daily to see that they are open. No repairs should be made on sprinkler system except by order of the fire marshal. While repairs are being made a man must be stationed at each sprinkler valve that is closed. The fire marshal should inspect all valves that have been closed upon completion of the work to see that they have again been opened. At every alarm of fire the inspector on duty should go immediately to the sprinkler indicator post controlling the district in which the fire is located in order to see that such valve is open.

Hydrants

All hydrants should be tested daily by the hand test and at least yearly (preferably in warm weather) by actually allowing water to flow.

Take off butt, open small valve fully, then open large central valve gradually and allow water to flow to its fullest extent.

Upon shutting off water, place palm of hand over hole uncovered by butt and if upon suddenly removing hand a hollow sound is heard the water has been properly drained from hydrant.

Records

Daily readings should be taken by means of a graphic recording meter (already installed) of the pressure at the "intakes" from the Pennsylvania Water Company's main which supplies both the sprinkler and the hydrant system. If for any reason, such record cannot be obtained, then the pressure on the gages at the "intakes" themselves should be read until such time as the graphic record can again be obtained.

Hose

All hydrant (2½-inch) hose should be tested at least yearly (during warm weather) by water being allowed to flow through at 110 pounds pressure.

All (1¼-inch) hose at sprinklers should be examined monthly to see if in good condition and should be tested at least yearly by water being allowed to flow through at 110 pounds pressure.

Hose Carts

Hose carts should be inspected daily to see if equipment is complete and in order including hose, two nozzles, washers for couplings, one ax, one steel bar, six hose straps, two spanner wrenches, one Siamese connection, one rope and one pulling rope.

Chemical Engine

All chemical engines should be inspected daily to see if equipment is complete and in order including one acid bottle in tank, two at either side, one bag of soda in tool box, two lanterns, one ax, one steel bar, one spanner wrench, one rope, one pulling rope, one three gallon fire extinguisher; also to see if rubber hose and valve are in working order.

Hand Portable Fire Extinguishers

All fire extinguishers including water pails, sawdust boxes, squirt guns should be examined daily to see if in position and ready for use.

Hose, Houses and Boxes

All hose houses and hose boxes should be inspected daily to see if equipment is complete and in order. The equipment in the hose houses should include 300 feet of 2½-inch rubber lined hose, two 1⅛-inch nozzles, two spanner wrenches for hose, two hydrant wrenches, four straps, washers for couplings, and diagram of hydrant and sprinkler systems showing how to shut off, etc., the different connections when a break occurs or other emergencies make it necessary. The equipment in the hose boxes should include 200 feet of 2½-inch linen (this will be replaced gradually by rubber lined) hose, one ax, two 1⅛-inch nozzles, 75 feet of rope, two spanner wrenches for hose, two hydrant wrenches, four straps, washers for couplings and diagrams of hydrant and sprinkler systems.

Fire Alarm Systems

Fire alarm boxes should be tested every Wednesday and Saturday morning; in addition two boxes, one controlling the west and one controlling the east side of the works should be tested daily.

Fire Pumps

Steam should be kept on fire pumps at all times, both day and night, and the pumps should be tested daily at 120 pounds pressure. They should further be started immediately upon any alarm of fire being turned in.

Fire Doors

Fire doors should be equipped with fuses and weights and should be inspected daily not only to see if in working order, but also to see

that no material of any kind is in position to prevent their closing should a fire occur.

Fire Escapes

All fire escapes should be inspected daily to see that they are free from all obstruction either on or near them and if provided with swinging steps at the bottom, these should be lowered and raised to see if in working order.

Aisles

All main aisles should be inspected daily to see that they are kept free from obstruction over a width of 6 feet and preferably marked with white lines so that this width may be maintained thus allowing fire apparatus to pass through.

Passageways to sprinkler risers, fire alarm boxes, water buckets, sawdust boxes, fire extinguishers, fire escapes, chemical engines, hose carts, hose houses, and hose boxes should likewise be inspected daily to see that they are kept clear.

All passageways for the ready exit of employes should be inspected daily to see that they are kept clear.

No industrial cars or trucks should be permitted to remain in aisles or passageways longer than necessary and in no case during the noon hour or at quitting time.

Inflammable and Refuse Materials

Inspection should be made weekly to see that such material as benzine, alcohol, gasoline, naphtha, soldering flux, varnish, shellac, linseed oil, waste, wiping rags, etc., are kept in minimum quantities only throughout the works and then only in approved safety cans or receptacles with covers.

Inspection should be made to see that dirty rags, soiled waste, scrap paper, lunch boxes, etc., are always placed in approved waste cans with covers and not allowed to be thrown about promiscuously. Such cans should be emptied at least daily..

All corners, storerooms, in out-of-the-way places should be inspected daily for cleanliness as well as to see that where inflammable materials are stored every precaution has been taken to prevent fire; for example, canvas duck treated with linseed oil should be stacked so there is ample ventilation all around and through the piles, being separated every inch of height by air spaces.

General

All heating pipes should have the dust removed from their exterior at least monthly.

All motors should be blown out at least monthly.

No shields made of paper or other inflammable material should be allowed on incandescent lamps.

All wiring should be regularly removed as fast is it becomes obsolete.

Discussion

An Organization Chart

By F. O. Clements, Dayton, Ohio.

I am submitting herewith an organization chart developed by the central safety committee of the National Cash Register Co. at the time I was connected with this company. Most concerns fail to do fire prevention work due to the fact that they do not obtain definite organization and assign specific duties to particular individuals. It is, of course, essential that sufficient drills be carried on to be absolutely certain that the men are fully acquainted with their individual duties. You will note also that this organization scheme calls for definite monthly inspections of fire hazards.

Personally, I think it very advisable for every concern of any size to have committees of workingmen devote several hours per month to safety. These men should be allowed time to make inspections and should, of course, be permitted to make suggestions. One of the great faults of industry as it exists today, is due to the fact that the individual has no opportunity to do creative work, and none of us are satisfied with our daily tasks, unless we recognize that the work is very much worth while, and that we furthermore have some little share in its planning and in the method of execution. Undoubtedly, there is no word in industry more important than the word "co-operation". No matter how able a person, if he cannot co-operate with others his usefulness is very much hampered and often the organization would be better without him.

The point I wish to make is that men cannot co-operate with others unless we give them practice in co-operation. Safety work by the rank and file is a short step toward the realization of this ideal. It seems to me, things do not get done unless there be specific organization to insure the carrying out of the task. For that reason I believe that we should urge

simple organization for safety, and incidentally fire prevention is only one of the elements of safety work.

FIRE PREVENTION ORGANIZATION OF NATIONAL CASH REGISTER CO.

Fire Drills for Fire Service

Day Organization

Chief.
Assistant Chief.

1.—Crews for hose stations appointed by the foreman and chief. (A checking system to be registered with the employment department for information when men on crews leave employ).

2.—Crews for outside hose reels appointed by chief.

3.—Crew for auto chemical appointed by chief.

4.—Crew of assistance appointed by chief.

Plumbers (gas)
Electrician
Salvage Corps
Operator of Fire Doors
Man familiar with yard system
278 Chemical Outfits
154 Pyrenes
371 Pails

5.—Regular drills for the inside of the factory shall be held on the first Monday of each month, 10 minutes before quitting time in the afternoon.

6.—Regular drills for outside crews shall be held as above except when weather does not permit—must include making hose connections with hydrants, unreeling and stretching hose without kinks, breaking and making couplings, attaching play pipes, carrying hose up ladders, holding play pipes, moving and carrying hose lines under water pressure, etc.

7.—More efficient equipment for crews:

Waterproof coats
Mittens for cold weather
Rubber boots
Caps, etc.
Lanterns.

8.—Crew's knowledge of the location of ladders.

Night Organization

Chief.
Assistant Chief.
Foreman.

1.—Inside crews for hose reels (Watchmen).

2.—Outside crews for hose reels (Plant Inspection Dept., 30 people).

3.—Auto Chemical crew.

4.—Crew of assistants:
- Plumber
- Electrician
- Salvage Corps
- Operator of Fire Doors
- Auto for Emergency

5.—Crew for fire pumps, boilers, auxiliary pumps, engines and turbines

6.—Notification of Officials.

Inspection Work for Fire Prevention

1.—Foremen's duties.

2.—Plant Inspection men's duties (day).

3.—Watchmen's duties.

4.—Monthly inspection of entire plant by chief or his assistant. This inspection to cover every nook and corner and a written report given to the central safety committee of any bad conditions, disorderly storage; in fact, any fire hazard.

5.—Monthly inspection of all fire fighting equipment.

Starting and Quitting Work Signals

Power House.
- Whistle, Fire Drill.
- Bells.
- Bells, Relay, Air Whistle.

Telephone Exchange.
- Klaxon Horns:
  - Power House (1).
  - Building No. 1.
  - Building No. 6.
  - Building No. 9.
  - Building No. 18.
  - Lumber Yard.

Importance of Co-operation

By Francis P. Sinn, Palmerton, Pa.

I think the several points made by Mr. Clements are well taken. Too much stress cannot be put on the importance of co-operation from the foremen and workmen, and I quite agree with Mr. Clements that it is impossible to get this co-operation unless the men are given an opportunity to practice it. Further, I believe that from the co-operation of workmen along safety and fire prevention lines, it is often found that certain men down the line are fitted for advancement. If no chance is given to the workmen along such lines, these men may go by unnoticed.

Application of Pulverized Coal to the Air Furnace

By W. R. Bean, Naugatuck, Conn.

I will preface my remarks on this subject by emphasizing the need, which will be acknowledged by all who have had actual experience in the operation of air furnace in melting malleable iron, for some improved method of firing this furnace which will be less laborious and more dependable than the present method of hand firing. While more is known today than in past years regarding the way in which hand firing of the malleable melting furnace should be done, it is questionable if there has been any decided improvement in the results obtained, due to the class of labor on which it is necessary to depend for work of this character.

Aside from the limited use of the open-hearth furnace in melting malleable iron; a very small number of furnaces fired with oil or natural gas; and the recent application of the electric furnace as a unit in the melting and refining process; the use of which, however, will no doubt be confined for some time to come largely to new foundry plants, we are dependent upon gas coal as the fuel for melting malleable iron, the firing of which may be accomplished by hand, by mechanical stoker and by introducing coal in pulverized form.

Hand Firing Cannot Be Uniform

The essential factor in the burning of any fuel is the proper proportioning of air to the combustible available for burning at a given time. It is obvious that with hand firing there can be no uniformity in this essential feature because the amount and size of the combustible available is constantly varying. When coal is thrown on a hot fire bed, the volatile products are rapidly driven off with the result that there is

not sufficient oxygen present for complete combustion, the supply of air being constant, or if there is sufficient for this condition there must of necessity be an excess as the coal burns down between firing periods.

The mechanical stoker has been tried out on the air furnace many times but in only a few instances has the equipment installed remained in service for any considerable period. At present I do not know of any air furnaces, melting malleable iron, which are being fired with a modern type mechanical stoker, although in one plant there are several furnaces used for melting cast iron for special purposes, which are being successfully fired with mechanical stokers of the underfeed type.

For permission to use the figures on pulverized coal firing which I will present, covering a number of heats melted with pulverized coal in a furnace at the Deering works of the International Harvester Co., Chicago, I am indebted to that Company and to the Metals Production Equipment Co., Springfield, Mass., successor to the Quigley Furnace & Foundry Co. Thirty-six heats in all were taken as will be seen by reference to the tabulated results. These were not sufficient to determine either the practicability or impracticability of the method but the results obtained appeal to me as having sufficient merit to justify some progressive organization in carrying the matter further, especially in plants where pulverized coal is now being used for annealing purposes.

Fundamental to success in the operation is the kind of fuel used and this cannot be very different than that which it has been found necessary to use for best results in hand firing. Coal high in volatile combustible matter—30 per cent or over—is very desirable and the ash content should be below 10 per cent and the sulphur below 1.5 per cent. However, slack coal from the screened coal generally used for hand firing air furnaces can be satisfactorily employed, the principal objection being the higher ash and sulphur content.

Effect of Deposit of Ash Over Charge

Just how detrimental the deposit of ash over the charge before melting down and over the bath after melting will be, is a question that is yet to be determined. With a suitable

combustion chamber and burner this probably would not cause serious trouble. However, there is a considerable total quantity in the fuel to be cared for. For example, in a 20-ton heat, assuming 800 pounds of coal per ton of iron and 10 per cent ash, there would be 1600 pounds of ash to dispose of and it is a matter of importance as to where this is deposited. Obviously it is advantageous to deposit it as much as possible in the combustion chamber and with a view to readily disposing of this deposit, one company in the pulverized coal equipment business has developed a combination of low-pressure feeder, burner and combustion chamber, whereby the majority of the non-combustible is precipitated before the heating zone of the furnace is reached. The point of deposit of ash is dependent upon a number of factors among which are fineness of coal, point and completion of combustion, and velocity resulting from draft or pressure.

There is one point of importance in which the coal may to advantage be different from that used for hand firing, namely, that coal in which the fusing point of the ash is low has certain advantages over coal in which the ash has a high fusing point. Ash with a low fusing point will deposit earlier as slag. This is particularly advantageous for plants located in the west or middle west where the coal available at lowest cost generally has ash of a low fusing point although otherwise suitable for melting furnace firing by hand. In the matter of sulphur content of coal I have been unable to find any difference in the effect of this element on the metal between one method of firing and another, since it volatilizes in any case and passes over the bath with the products of combustion.

For quick combustion and high temperature, coal should be pulverized to a fineness of not less than 85 per cent of the total through 200 mesh and 95 per cent of the total through 100 mesh. Some operators found it advisable in open-hearth practice to pulverize to an even higher degree of fineness. The advantage to be gained from this will be found to exist equally with the air furnace and the open-hearth furnace, since high temperature is the end sought in both cases. Coal for pulverizing must be thoroughly dry, 1 per cent or under in moisture and preferably as low as 0.50 per cent. This is necessary not

alone for the proper mixing and burning of the fuel, but from the standpoint of cost of pulverizing. The cost of pulverizing is a variable factor in which many different elements, particularly the cost of power, are involved and can only be stated definitely under known conditions. Some large plants are pulverizing at a cost of approximately 25 cents per ton.

Altering the Furnace For Pulverized Fuel

The furnace on which the experiments were conducted was of good general design with stack of ample proportion. In making the change from hand firing to pulverized coal firing only minor alterations were required. The fire-box was converted to a combustion chamber by increasing the length to give sufficient travel of the coal and air mixture to get good ignition before impingement of the flame against bridge wall, which was allowed to remain as in hand-fired practice. The grates were covered over with about 6 inches of cinders to form a hearth for deposit of the slag from the ash in the fuel. The length of the melting chamber from bridge wall to bridge wall was 24 feet 9 inches, and the furnace was 7 feet wide at the front. The side walls were parallel for 11 feet back of the front bridge wall, from which point the furnace narrowed to 5 feet 6 inches at the rear flue or neck, the opening through which was approximately 420 square inches in area. The area of stack inside of lining was 1385 square inches.

Pulverized coal fires, with coal of proper dryness, fineness and volatile content, are very readily started, it only being necessary to light a small quantity of oily waste in front of a burner and start the coal and air feeds. With any reasonable amount of care, there need be no smoke or coke formed where there is sufficient flame-way in starting up a malleable melting furnace and of course there is none after the furnace and charge become hot. To prevent smoke and coke in starting, it is necessary to burn with a short flame and get complete combustion in the front of the furnace.

It will be well to have clearly in mind the distinction between a pulverized coal burner and a pulverized coal feeder or controller. The function of the latter is to supply uniformly to the burner the quantity of coal which it may be desirable

or necessary to burn to produce the required temperature. The mixture of coal and air takes place in the burner, combustion beginning soon after this mixture enters the combustion chamber, the exact point at which this takes place being dependent upon velocity, air proportion and other factors.

Tabulated Results of Tests

Turning now to the figures in the table at the end of this paper we find results, in coal consumption per ton of iron, melting time and silicon loss, all the way from poor to exceptionally good, the latter applying particularly to heats Nos. 34 and 35. There are 12 different furnace arrangements indicated under the heading, "Furnace Arrangement." In some cases the change between one arrangement and another was only slight, yet it was considered of sufficient importance to record; in other cases the change was a radical one. Time will not permit, nor is it the purpose of this discussion to give in detail all of the many factors having a bearing on the results obtained.

Furnace arrangement No. 11 produced the best results, the figures for heats Nos. 34 and 35 comparing favorably with the very best practice under hand firing methods. The change from arrangement No. 10 to arrangement No. 11 did not in any way involve the coal feeding or burning equipment, but was one of furnace construction. It consisted of lowering the roof of the furnace so as to bring the nozzle outlet of the top blast into the proper relation with the bath and directing this in such a way as would bring the point of highest temperature in direct contact with the metal and in providing sufficient volume of air through the top blast.

In judging the coal consumption figures it should be remembered that many of the heats were single heats only, taken after the furnace had been idle for days or for weeks and that a large amount of fuel was required to bring the furnace up to the temperature that would exist in a furnace in regular operation for one or two heats a day.

The period which is of greatest interest because of the more nearly continuous operation is that from July 15 to 31 inclusive with furnace arrangement Nos. 10 and 11, heats 20 to 35 inclusive. During this period we tried to get the

proper proportion of air and fuel and in this we were only partly successful because arrangement could not be made to continue the test for a period sufficiently long to work the matter out to a final conclusion. There was, during this time, a fairly regular decrease in coal per ton of iron melted, in time per ton melted, and in silicon loss from oxidation during the heat. The relation between coal per ton and silicon loss is of particular interest. In looking over these figures in light of more recent experience, it is evident that the high coal consumption was largely the result of excess air, although there was not much difference in the operation under furnace arrangement Nos. 10 and 11.

Results Obtained With Partial Blast

Heats Nos. 1 to 35 inclusive were taken with all of the air for combustion supplied under pressure. Heat No. 36 was taken with something more than half the air taken in by induction, only the top blast and the air necessary to convey the coal into the burner being supplied under pressure. Not much can be based on the results of a single heat, but from what has been accomplished in locomotive and stationary boiler firing under the induced draft system, I consider this method for air furnace operation one well worth considering.

The use of pulverized coal on the air furnace brings to my mind two other matters which may be well worthy of serious consideration. Waste heat boilers may be more generally employed because the method of firing lends itself readily to the maintenance of a low fire between heats to maintain the boiler capacity required in the majority of malleable foundries during the off hours of operation. Furthermore where the steam supply is lacking, combinations of waste heat and direct firing are now being installed to provide a 150 to 200 per cent of nominal horsepower rating output, which is most advantageous in plants where power is required for other than foundry operation. There are, no doubt, some and perhaps many localities in which an agreement for exchange of power with local power distributors could be effected which would result in a material saving as compared with the present cost of air furnace melting and power supply. The other point which

presents itself is the possibility of using silica brick in furnace lining, the ability to keep a furnace hot continuously making the use of this kind of brick practical.

The air furnace as at present operated is admittedly a wasteful piece of equipment yet it lends itself better to the varying requirements of the average malleable foundry than does any other type of melting furnace and while electric melting or more correctly perhaps, electric heating of malleable iron may make further progress, the air furnace is destined to continue to be the principal melting unit in the average malleable foundry for some years to come.

One of the achievements credited to the late David H. Browne, chief metallurgist of the International Nickel Co., is the practical application of pulverized coal firing to reverberatory smelting furnaces. I know that there are several installations in successful operation in the copper and zinc refineries and it would seem that the advantages to be gained in the malleable industry should be fully as great.

The probable or at least possible advantages to be derived from pulverized coal firing of the air furnace may be summed up as follows:

First.—The elimination of the exhausting labor of hand firing, permitting the employment of more intelligent men in operating the furnace.

Second.—The elimination of the clinker problem which at this time is unusually serious owing to conditions existing in the coal market.

Third.—A reduction in the cost of fuel over present hand-fired practice by improved combustion, and in some cases by the use of lower priced fuel.

Fourth.—The elimination of smoke.

Fifth.—A more advantageous use of waste-heat boilers.

Sixth.—A reduction in cost of furnace maintenance by the use of silica brick.

RESULTS OF TESTS WITH PULVERIZED COAL

Heat No.	Date 1914		Charge, pounds	Coal per ton of iron, pounds	Duration of heat, hr.	min.	Time per ton melted, min.	Silicon loss, per cent	Furnace arrangement, No.	Condition of Furnace
1	Mar.	28	12000	....	5	6	50	...	1	Cold
2	Mar.	30	12000	....	7	15	71	...	2	Cold
3	April	4	12000	1120	4	15	42	0.51	3	Cold
4	April	6	20000	1536	8	15	49	0.58	3	Cold
5	April	7	20000	1198	..	..	..	0.44	3	Cold
6	April	8	20000	1192	7	25	44	0.43	3	Cold
7	April	8	20340	874	5	40	33	0.15	3	Hot
8	May	18	20000	1066	9	0	54	0.49	4	Cold
9	May	20	20000	1134	7	30	45	0.51	4	Cold
10	May	21	23000	1508	..	..	..	0.48	4	Cold
11	June	8	20300	1536	9	55	57	1.15	5	Cold
12	June	9	20350	1198	9	0	52	1.21	5	Cold
13	June	10	20000	1368	8	30	51	0.92	5	Cold
14	June	12	20210	1324	8	30	50	0.32	6	Cold
15	June	16	20000	1754	9	15	55	0.51	7	Cold
16	June	19	20145	1558	7	15	42	0.31	8	Cold
17	June	22	20000	1216	6	30	39	0.34	9	Cold
18	June	23	20000	1346	..	..	..	0.49	9	Cold
19	*June	24	20000	1346	..	..	..	0.58	9	Cold
20	July	15	20000	1696	9	15	55	0.83	10	Cold
21	July	16	20000	1682	7	0	42	0.87	10	Cold
22	July	17	20300	1056	5	30	32	0.41	10	Cold
23	July	20	20000	1140	6	13	37	0.48	10	Cold
24	July	20	20340	794	4	52	28	0.39	10	Hot
25	July	21	20760	1250	6	0	36	0.44	10	Cold
26	July	21	24610	822	4	43	23	0.34	10	Hot
27	July	22	20000	970	5	0	30	0.24	10	Cold
28	*July	22	20000	970	4	15	25	0.30	10	Hot
29	July	23	20000	1056	5	15	31	0.42	10	Cold
30	July	23	20000	966	3	50	23	0.47	10	Hot
31	July	27	20200	1322	6	34	39	0.80	10	Cold
32	July	28	30000	1124	8	17	31	0.66	10	Cold
33	July	30	20000	922	4	20	26	0.46	11	Cold
34	July	31	24500	760	4	40	22	0.43	11	Cold
35	July	31	24000	620	3	37	18	0.26	11	Hot
36	Aug.	4	20000	800	4	10	25	0.43	12	Cold

*Indicates coal weights were not separated between heats Nos. 18 and 19 and Nos. 27 and 28.

Discussion

Mr. S. Griswold Flagg, III:—I would like to ask a few questions in regard to this coal. Under present coal conditions we are all interested in using what we get from the mines, not what we want. It has occurred to me that oil would be less difficult to adapt to an air furnace than pulverized coal. I wonder if Mr. Bean can give us any comparative costs of melting with oil and with pulverized coal?

Mr. W. R. Bean:—That question is probably best answered by the experience of the open-hearth steel producers, where pulverized coal is employed. I know that it has been stated by one user that if oil went to 2 cents a gallon, he wouldn't change back from pulverized coal to the oil firing. I know of one small plant in New York state where, for years, fuel oil has been the fuel used. At the plant of the Erie Malleable Iron Co. oil was tried on a natural-draft furnace melting heats approximately of 40 tons. It melted, but the operation was not as satisfactory as hand-firing. The oxidization was more difficult to control and it didn't seem that we could quite reach the temperature that hand-firing gives.

Now, there are complications in the pulverized coal burning proposition, but they are not so very great. As I was counting up this morning, there are 11 malleable iron foundries, to my knowledge, operating annealing ovens fired with pulverized coal.

Mr. Enrique Touceda:—I think Mr. Bean has made a mistake in connection with his statement in regard to cost of maintenance. Also I do not quite understand how you could successfully use silica brick in a process that is not continuous. I think they will spall and crack. I know a concern that has changed from a hand-fired furnace to pulverized coal in the manufacture of wrought iron, and the cost of maintenance has increased. The side walls and roof deteriorate very rapidly,

and they have had a great deal of difficulty in getting a grade of brick which would stand up to the work.

I am a great believer in pulverized coal, because we all know that through its means one can get a very intense temperature cheaply. I think if you ran an air furnace continuously, that the conditions would admit the use of silica brick.

MR. BEAN:—The suggestion for the use of silica brick was that the furnace would be maintained at a temperature sufficient to protect the brick during the hours between the second heat and the fire-up of the heat the next morning.

As I understand it, our silica brick can come down to about 1500 degrees, provided the drop isn't too quick, without serious injury. That was the thought in connection with it, and under no other condition could the silica brick be used.

Now, as to the cost of maintenance, what we did at Deering Works was to take 11 consecutive heats without any repairs to the furnace sides. As I recall the operation, there was very little, if any, more damage to the walls than with hand firing, except to the face of the bridge wall, against which the flame impinges in entering the furnace. That does deteriorate more rapidly.

THE CHAIRMAN, MR. J. P. PERO:—I believe it won't be long before we will all get away from handfiring. Where one fireman will fire his two heats without any effort through the day in ordinary weather, through the hot weather, and particularly in these times, it takes three or four.

There is an argument that hasn't been brought out, thus far, against hand-fired furnaces and that is, the lack of uniformity of product when they are used. Now, the first essential in the operation of a melting furnace is uniformity of product. I know positively that I have much better control of the chemical content of the iron that I am melting in an oil furnace on which I have been experimenting for several months, than I have on any of my handfired furnaces. I know positively that the wear and tear on that oil-fired furnace is very much less than on our hand-fired furnaces. I know positively that we get quicker and better heats; in fact, you can almost set your watch by the heats; and we have a control on that furnace that you cannot obtain on hand-fired furnaces.

We are so well pleased with our oil furnace that we are going to equip three more furnaces with oil burners and put in a 135,000-gallon tank to store our oil.

Now our daily reports do not show any economy of oil over coal. There is a decrease in labor cost and there is a decrease in cost of repairs, but the great factor is uniformity. You can oxidize, if you want to; and you do not have to oxidize much if you don't want to. The furnace is controlled by turning a little valve.

I have been surprised to find that with oil I can carry a flame just over my bridge wall, if I want to, and only a little further, and it does the work. I am not burning out my stack and I am not sending much gas up the stack. I am bitterly opposed to hand-firing as compared with the other methods which I have just been telling you about. I haven't had any opportunity to go into the pulverized coal. For many reasons I preferred to try oil, and I am very strong for oil. As I say, I haven't been able to show any economy day by day, but I think that ultimately, at the end of the year, the uniformity of product, the decreased cost of labor, the decreased cost of repairs and the fact that we can start a heat and get a fixed amount of iron with the cold furnace proves the case for oil firing. It also betters labor conditions. Your molders are better satisfied. They know just exactly when that heat is coming and they are asking us when we are going to have the rest of our furnaces fixed up. Everybody in our shop is delighted with the oil-fired furnace, and I think it will be but a very few years before we will find no hand-fired furnaces in the malleable iron business.

Mr. W. R. Bean:—In a comparison of pulverized coal and oil, it goes right back to the B.t.u. value of the two fuels, and the cost per unit. As to the burning of the two fuels, those who have had experience with both prefer pulverized coal, in the matter of control, to oil. It is possible, I believe, to burn pulverized coal with less excess air than it is possible to burn fuel oil. You can get your flame just where you want it. Some favor a pulverized coal furnace without a bridge wall. I am not sure that this is the right method, because when you start your furnace with a cold charge you are likely to get a

coke formation which will materially interfere with the melting. A top blast I should consider essential. The top blast does more in the operation of an air furnace than to simply provide the air necessary to complete combustion in the melting chamber. There is something mildly approaching the bessemer condition in the impingement of the flame on the bath, which clears up all the slag, exposes the metal to the maximum temperature and gives you a high temperature point. It also creates a circulation of the metal in the bath that is not provided except in the presence of a top blast.

Mr. J. B. Deisher:—One point in favor of using oil is that you do not have any increase in sulphur. Another point is that you wouldn't have ash to take care of with the oil, as you have with coal.

Mr. Bean:—Sulphur content is a big question in the production of malleable iron. Very good malleable can be and is regularly produced with a sulphur content beyond what used to be considered entirely dangerous. Of course, there is the question of ash, but in almost all districts when you figure your coal and oil cost on a B.t.u. basis, the cost is so entirely in favor of coal that it offsets any small item.

The Theory of the Modern Waste-Heat Boiler and the Possible Application of Such Boilers to Malleable Melting Furnaces

By ARTHUR D. PRATT, New York

It has been said that steam generating apparatus in general use today represents nothing essentially new. If this statement is limited to boiler pressure parts, and a distinction made between the improved details of construction and changes in design, it may be broadly accepted as correct.

There is one class of boiler which perhaps should not be included with those covered by the foregoing statement, namely, the waste-heat boiler in the state of development which it has reached within the past few years. Such boilers, while they differ from standard direct-fired types rather in arrangement of heating surface than in radical alternations of design, still utilize a theory that as yet has been tried only in the waste-heat field. And for that reason they may be considered something new in the art.

The use of boilers for the reclamation of heat in the waste gases from various industrial furnaces is not new. The first water-tube boiler installed for this class of work was in connection with a puddling furnace at Baltimore in 1874 and for a number of years previous to that time cylinder and flue boilers had been used for this purpose.

Many boilers have been installed for use with waste gases. Until 1912, however, practically all such installations were in connection with furnaces discharging gases at high temperature, and it was ordinarily considered impracticable to generate steam commercially with waste gases the temperature of which was below 1600 degrees Fahr.

Practically all the installations prior to 1912 consisted of direct-fired types of boilers or such types but slightly modified and so arranged as to allow the waste gases to pass over the heating surface in place of the products of combustion from a coal fire. The modifications from the standard direct-fired types, and the main feature of design of the boilers built especially for waste-heat work, consisted usually of an increase in gas passage area to minimize the frictional resistance through the boiler.

A New Type of Boiler

What may be called the modern type of waste-heat boiler was developed as a result of a study of the rates of heat transfer determined from a great number of reliable boiler tests. The rates so determined indicated such possibilities in heat absorption from low and high temperature waste gases that an extended series of experiments was undertaken to determine definitely the laws governing the rate of transfer of heat from a hot to a cooler medium. These experiments, published under the title, "Experiments on the Rate of Heat Transfer from a Hot Gas to a Cooler Metallic Surface",* substantiated the figures as determined from actual boiler tests, and may be considered the basis for the design of the modern waste heat boiler.

The effect of gas velocity on heat absorption had, to a certain extent, been appreciated, but a study of the tests, and the experiments to which reference has been made, showed conclusively that its function, at least in the waste-heat field, had not been fully realized.

Temperature Difference and Gas Velocity are Factors

For a given amount of heating surface and a given gas weight, the total heat absorption will be dependent upon the mean temperature difference between the absorbing surface and the cooling medium, and upon the rate of heat transfer, ordinarily expressed in B.t.u. per hour per square foot of surface,

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*Experiments on the Rate of Heat Transfer from a Hot Gas to a Cooler Metallic Surface, by the Babcock & Wilcox Co., 1916.

per one degree difference in temperature. The transfer rate in turn is dependent upon the mean temperature difference and the gas velocity. Because of the wide fluctuation in the density of the gases with the temperatures, and hence in the velocity, it is easier to express such velocity in terms of gas weight per square foot of gas passage area, and it is so expressed in considering the design of the modern waste-heat boiler.

The effect of gas velocity on heat transfer is best indicated by the consideration of a hypothetical case.

Assume that with a given weight of gas and a given amount of absorbing surface, we have two sets of temperature conditions, under the first of which the mean temperature difference between the absorbing surface and the gas is 900 degrees, while under the second set this mean difference is 600 degrees. Obviously, if the total heat absorption in the two cases is to be the same, the transfer rate for the lower temperature difference must be 1.5 times that for the higher difference.

The heat-transfer experiments indicated that with moderate gas velocities the effect of temperature difference on the rate of heat transfer is small as compared with the effect of gas velocity. Neglecting for the moment, then, the fact that the temperature difference in the two assumed cases is not the same, and considering the transfer rate as dependent only on the gas velocity, with the gas weight and amount of surface fixed as above, the only way in which the total heat absorption under the second set of temperature conditions could be made equal to that under the first set—that is the only way the transfer rate could be increased 50 per cent—would be through the rearrangement of the given heating surface to give the necessary increase in gas velocity.

Fig. 1, a partial reproduction from the experiments on the rate of heat transfer, indicates clearly the effect of gas velocity on transfer rates. This shows such rates for mean temperature differences of 600, 800 and 1000 degrees, which would cover the range to be found in non-regenerative malleable furnace waste-heat practice. It is true that the experiments were conducted with a gas passage channel of given dimensions and that supplementary experiments proved that a change in

the linear dimensions had an effect on the transfer rate. On the other hand, we are for the present endeavoring to show the very great bearing that gas velocity has on transfer rate, and for this purpose Fig. 1 serves admirably.

If the heating surface for our first set of temperature

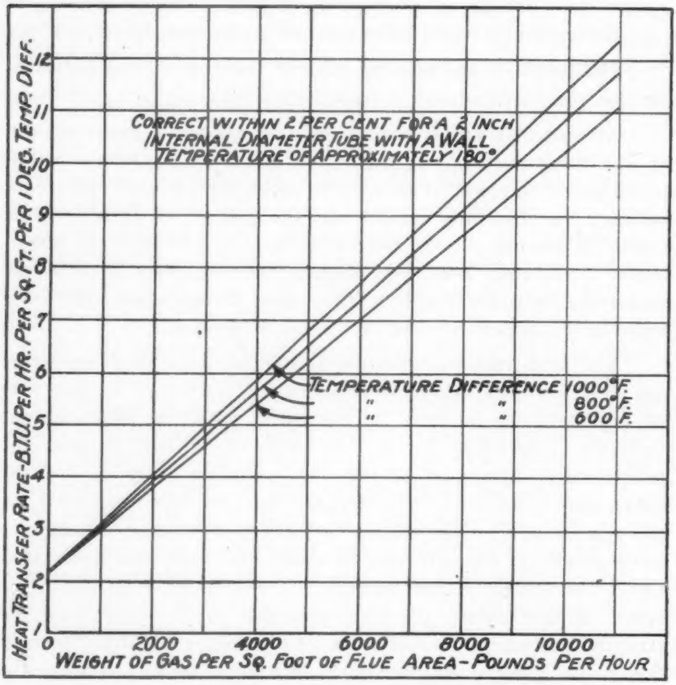


FIG. 1—DIAGRAM SHOWING EFFECT OF GAS VELOCITY ON HEAT-TRANSFER RATES

conditions were so arranged as to give for a mean temperature difference of 900 degrees, with a gas weight of 2000 pounds per hour per square foot of gas passage area, provided Fig. 1 is accepted as approximately correct for a modern waste heat boiler, this same surface, to give the 50 per cent increase in transfer rate necessary for an equal total absorption with a

temperature difference of 600 degrees, would have to be so arranged to give a gas weight of 6800 pounds per hour per square foot of area. This consideration makes plain the theory upon which the design of the modern waste-heat boiler is based, namely, high gas velocity.

The gas velocity which will give the best commercial return for different classes of waste-heat work will vary with the temperature of the gas, the amount and nature of the dust carried by the gas and, to an extent, upon the draft requirements of the primary furnace. Experience with practically all of the types of furnace from which waste gases are available has pretty definitely determined what such velocity should be for a specific set of conditions. It is hardly within the scope of the present paper, however, to discuss this phase.

It may be generally stated that other things being equal the higher the temperature of the waste gas the higher should be the gas velocity. A partial explanation of this statement is given by a consideration of the heat absorption through radiation in the furnace of a direct-fired boiler as compared with that in a waste-heat unit utilizing high temperature gas. In direct-fired practice such absorption, in terms of the total heat absorption, is very much greater than is ordinarily appreciated, and for different sets of furnace conditions the absorption through radiation per unit of exposed surface will vary as the fourth power of the absolute furnace temperature.

A Fourth Power Ratio

Compare, then, a direct-fired boiler equipped with an underfeed stoker and a waste-heat boiler, assuming that the amount of absorbing surface and the amount of radiating surface is the same in the two units. The furnace temperature in the case of the underfeed stoker will probably be in the neighborhood of 2800 degrees. If the temperature of the gases entering the waste heat boiler is 2000 degrees, this may be taken as the furnace temperature. The total absorption through radiation then will vary as

$$(2800 + 460)^4 : (2000 + 460)^4$$

or the absorption, in the case of the direct-fired boiler, will be somewhat over three times as great as that in the waste heat unit.

This difference is further aggravated by the fact that in the modern waste-heat boiler the amount of surface exposed to the radiant heat of the furnace is very much less in proportion to the total heating surface than in direct-fired practice.

Under such conditions then, for a given gas weight, the proportionate amount of heat that must be absorbed through convection must be very much greater in the waste heat than in the direct-fired boiler if the exit gas temperatures in the two cases are to be brought to a comparable degree. To increase the absorption by convection it is necessary to increase the heat transfer rate and this, as we have seen, is accomplished by an increase in gas velocity.

Early Practice Opposed to Modern Theory

It is of interest to note that the principle of the early waste-heat boiler installation and the theory as above described, upon which the modern waste-heat boiler is based, are diametrically opposite.

Previous to 1913 the sole factor that appears to have been considered in waste-heat installations was the non-interference in the operation of the primary furnace. Almost universally this meant non-interference with the draft at the furnace outlet and for such a condition it was necessary to reduce the draft resistance through the boiler to a minimum. This necessitated large gas passage areas and consequently low gas velocities. The resulting exit gas temperatures were high but were considered rather advantageous in that they enabled a given height of stack to produce a greater draft than could be expected under normal direct-fired conditions.

With a modern design of waste-heat boiler, on the other hand, high gas velocities are necessary to give the desired heat-transfer rates; gas passage areas, therefore, had to be appreciably reduced below the standards for direct-fired practice. This reduction in gas passage area gave a greatly increased draft resistance through the boiler and, further, the low exit gas temperatures secured through the high heat-transfer rate reduced considerably the draft to be expected from a given height of stack.

These two factors have made it impracticable in almost all classes of waste heat work to meet the draft requirements of the primary furnace with its attached boiler unit by means of a natural-draft stack. The remedy was naturally found in the use of an induced-draft fan, but it was the necessity for the use of such apparatus that was, at first, the stumbling block in having the advantages of the modern waste heat boiler recognized. Furnace operators could not rid themselves of the impression that any boiler which required an induced draft fan to overcome the draft resistance through it must of necessity interfere with the proper operation of the furnace.

Fans Proved a Help

The first few installations of the modern waste-heat boilers with their fans definitely answered this contention of the furnace operators. These boilers were set in connection with open-hearth steel furnaces and, due to the increase in the available draft and the better regulation of such draft, the fans instead of being a hindrance to the furnace operation proved an actual help. It was found that through the installation of fans the length of time required per heat was materially reduced. Such a reduction in time was equivalent to an increase in furnace capacity, and for eight furnaces of different rated tonnage investigated with a view to determining the effect of the boiler and fan installation on furnace operation, the average increased capacity was 12 per cent. As successive waste-heat installations were made with other types of furnaces, improved furnace operation was almost universally noted, though the improvement was perhaps not so marked as in the case of the open-hearth furnace where the draft requirements are the most exacting that have as yet been encountered in waste-heat work.

The induced-draft fans required a certain amount of power for their drive, such amount, for a given gas weight, being dependent upon the draft suction necessary at the fan inlet. It is the practice today to drive such fans by turbines and this type of apparatus has been developed to a state where, considering its size, the steam consumption is low. Practically all of the heat in the exhaust steam from such turbines can be

readily returned to the boiler in the feed, and the net deduction from the total boiler output, due to fan drive, is practically negligible. In a series of tests where the draft requirements at the fan approach the maximum that has as yet been used, the gross power required for the fan drive was 13.1 per cent of the total boiler output. Of the total heat of the steam

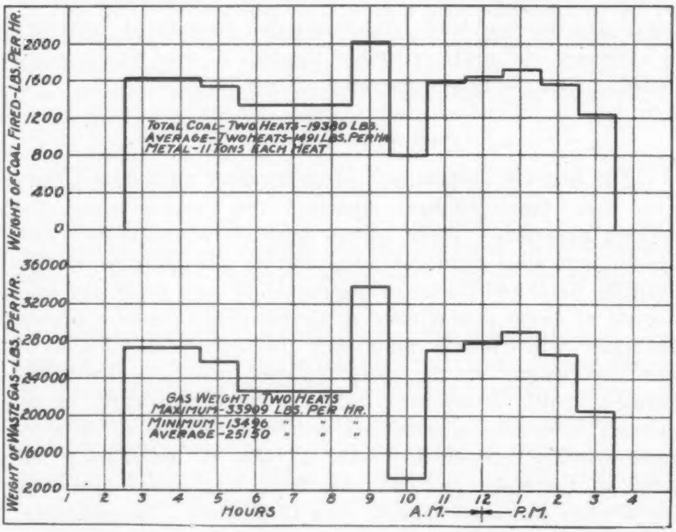


FIG. 2—AMOUNT OF COAL BURNED PER HOUR DURING TWO TEST HEATS AND GAS PRODUCED

used in the turbine, 91.1 per cent was returned to the boiler feed through individual heaters, so that the net deduction for fan drive was but 1.17 per cent of the gross output.

Gas Velocity Dependent on Draft Requirements

The statement was made above that for a given type of furnace the gas velocity through the attached boiler which will give the best commercial return is dependent to an extent upon the draft requirements of the furnace. This velocity affects

the draft resistance through the boiler and, hence, the amount of power required for the fan drive.

The total draft suction which the fan must show at its inlet is made up of the draft required at the outlet of the primary furnace, that required in overcoming the resistance through connected flues, and that required in overcoming the resistance in the boiler. The heat represented in the power required to produce this total draft suction, expressed in terms of steam consumption of the fan drive, must obviously not be greatly in excess of an amount which can be utilized in heating the feed for the individual boiler which the fan serves. Where the steam consumption of the fan drive is above such an amount, the power required is directly chargeable as a loss in the boiler output.

The net allowable deduction due to the steam consumption of the fan drive with a given furnace must be determined in each individual case from a proper consideration of the conditions of each installation. In general, the greater the draft required at the outlet of primary furnace the greater is the care necessary in the design of the boiler to give the proper gas velocity.

It is natural that the modern waste-heat boiler, embodying as it did principles that were new in boiler design, was at first developed in connection with waste gases whose temperatures had hitherto been considered far below that necessary for successful commercial steam generation. The first boilers, as stated, were installed in 1913-1914 in connection with regenerative open-hearth steel furnaces where the gas temperatures at a point corresponding to the boiler inlet varied from 950 to 1200 degrees.

Success Was Immediate

The success of the first installations was immediate. It was found that with entering gas temperatures as low as 1150 degrees, a properly designed boiler could develop from 70 to 80 per cent of its normal rated capacity. That the steel industry as a whole fully appreciated the enormous savings accruing through the utilization of steam generated from gases hitherto discharged to the atmosphere as waste, is indicated by

the fact that there have been purchased and installed within the past 3½ years for use with existing and new open-hearth furnaces approximately 100,000 rated boiler horsepower. The total output of the furnaces to which these boilers are attached is in excess of 10,000,000 tons per year.

A natural result of the success of the modern waste-heat boiler with low temperature gases was the application of the

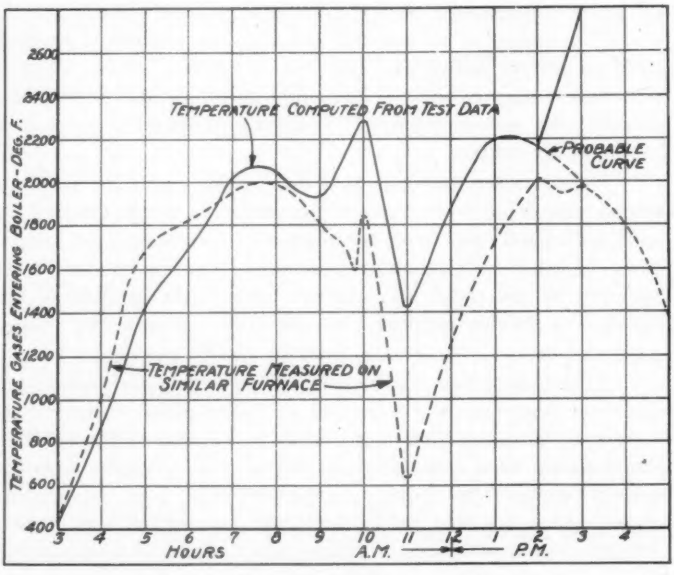


FIG. 3—GAS TEMPERATURE CURVES

same principles of design to boilers for use with industrial furnaces yielding high temperature gases.

Such gases had, as stated, been used for years for steam generation, but the results secured with the types of boilers ordinarily used were far below what our newly acquired knowledge of the laws governing heat transfer, and the experience gained with low-temperature gases would lead us to expect from the new design of boiler.

The following classes of industrial furnaces may be taken as typical of those yielding high temperature waste gases:

Copper refining furnaces, in which the exit gas temperatures vary over a complete cycle of operation from 700 to 2100 degrees, and average approximately 1500 degrees.

Heating and reheating furnaces, where the temperatures vary from 1600 to 1900 degrees.

Beehive coke ovens, where the temperatures in the flue at a point corresponding to a boiler inlet average from 1900 to 2300 degrees.

Installations of modern waste-heat boilers have been made with all of these classes of furnaces and in operation are as successful as are the boilers set with open-hearth steel furnaces.

Results Speak for Themselves

The results of a number of tests of the present-day waste-heat boiler with high temperature waste gases are given in a paper presented by the writer in 1916 before the American Society of Mechanical Engineers, entitled "The Utilization of Waste Heat for Steam Generating Purposes". These results are typical and speak for themselves. There is one test given in this paper that to the author's mind is particularly effective in substantiating the correctness of the high gas velocity theory as applied to boilers for use where waste gas temperatures approach coal-fired practice. The test in question is of a Babcock & Wilcox boiler containing 10,200 square feet of heating surface set in connection with a battery of beehive coke ovens.

At the time of installation, it was the intention to have this boiler handle the gases from a sufficient number of ovens to enable it to develop some 20 per cent above its rated capacity, and it was expected that the amount of gas necessary to develop this capacity would correspond to approximately 3500 pounds per hour per square foot of gas passage area.

The fan equipment furnished, however, was such as to enable a gas weight greatly in excess of this amount to be drawn through the boiler and during the test in question the weight per square foot of area was approximately 4800 pounds per hour. With this gas weight and an entering temperature of 2158 degrees, the boiler developed 192 per cent of its normal rated capacity and cooled the gases leaving the boiler to 477

degrees. The approximate transfer rate as determined in the test was 6.8 B.t.u. It is of interest to note how closely this figure checks with the rate as determined for a corresponding gas weight from Fig. 1. The mean temperature difference existing during the test was approximately 950 degrees.

In the Malleable Foundry Field

Numerous malleable melting furnaces were included among the various types yielding high temperature waste gases with which waste-heat boilers of the class we have termed "early design" were installed. Unfortunately for the purposes of the present paper, while the modern design of waste-heat boiler is giving satisfactory results with a number of high exit temperature industrial furnaces, no installation of such boilers has as yet been made in the class of work in which you are most interested. It is not possible, therefore, to give any actual results obtained from a modern waste-heat unit with malleable furnaces, but there is no apparent reason why such results should not be as wholly satisfactory as with other types of furnaces where the gas temperatures are comparable. Further, enough has been done, both in the theory and the practice of the modern waste-heat boiler, to enable us from a given set of gas conditions to compute within remarkably close limits the boiler capacity and amount of heating surface. A great number of carefully conducted waste-heat tests have been checked against the results theoretically computed for the conditions actually existing in the tests and in no instance has the difference between the computed and actual results been greater than 5 per cent.

On such a basis it is possible to take a given malleable furnace and from a record of the coal burned, the exit gas analyses and exit gas temperature to compute the performance of a given waste-heat boiler of the modern design. Such computed results are, of course, theoretical and possibly somewhat approximate, but our experience through the whole waste-heat field has been such as to lead us to trust computed results almost implicity.

Through the courtesy of the International Harvester Co., the author obtained data secured by the Arnold Co., engineer,

in 1910, in the course of a test on the operation of the first waste-heat boiler attached to a malleable furnace at McCormick works, Chicago. As is the case with numerous forms of industrial furnaces, the operation of no two malleable furnaces, even of the same dimensions, is alike. The data, however, agree in general with that obtained in the investigation of a number of similar furnaces and it appears that the operation of the Harvester furnace may be accepted as typical of the coal-fired non-regenerative malleable furnace.

Eleven Tons Per Heat

The furnace in question, rated at 15 tons, at the time of the tests was being operated at the rate of 11 tons per heat. As in all furnaces investigated, the first or cold heat was some two hours longer than the second or short heat and the coal consumption per ton of metal higher due to the fact that the furnace had been idle for some seven or eight hours previous to the starting of the fires for this heat.

This furnace had attached to it a vertical water-tube boiler rated at 400 horsepower, and the installation may be considered representative of waste-heat practice with high temperature gas previous to the introduction of the modern design of boiler. During the time that the furnace data was secured, a test was run on the boiler and it is thus possible to offer a comparison of the actual performance of an early installation with the expected performance of the waste-heat boiler of today.

The only data missing in the recorded results is the temperature of the gases entering the boiler and this, of course, is necessary for the computation of the expected performance of the proposed boiler. Such temperatures, however, may be determined within close limits of accuracy from the power developed by the existing boiler, the gas temperatures leaving the boiler and the weight and analysis of the gases passing through the boiler, all of these factors varying at different portions of the cycle in operation. The entering gas temperatures have been thus determined and checked within reasonable limits with gas temperature readings obtained in the investigation of a number of similar furnaces.

The comparison of the actual and expected performance is most clearly indicated by a graphic representation and this is the method followed.

Coal and Gas Weights

Fig. 2 shows the amount of coal burned per hour during the two heats. From this coal weight, its analysis, and an analysis of the flue gases covering the different portions of the cycle, the weight of gas available for the generation of steam may be computed. These gas weights are also shown in Fig. 2.

The temperature of the gases entering the boiler for the different portions of the cycle computed from the horsepower developed by the existing boiler, Fig. 5, the exit gas temperatures from these boilers, Fig. 4, and the gas weight as given in Fig. 2 are shown in Fig. 3. A temperature curve obtained from a furnace similar to that tested is also shown in Fig. 3 to indicate that the computed temperatures are in line with general malleable-furnace practice.

The only point in the computed temperature curve which appears questionable is the final point. At that time no coal was being fired and the furnace was being tapped. Large quantities of air, which were not measured, were passing through the furnace and being heated in such passage. The boiler capacity developed would thus be the result of heat absorption from a large volume of comparatively low temperature gas, consisting mostly of heated air, rather than a smaller volume of high temperature gas which was actually the products of combustion, and for this reason the weight of gas corresponding to the amount of coal fired for this particular portion of the cycle cannot be relied upon as a means of computing the temperature of the gases entering the boiler at this time. Unquestionably the gas temperature is falling off at the time the heat is being tapped and the direction of the temperature curve is probably as indicated by the broken line in Fig. 3. The probable curve would correspond in general direction to that at the end of the cold heat.

The exit gas temperatures from the boiler installed and the capacity it developed for different hours of the cycle are shown in Figs. 4 and 5, respectively.

For the conditions of gas weight and temperatures as determined by this test, the modern high gas-velocity waste-heat boiler which would probably give the best commercial return would contain approximately 2620 square feet of heating surface and would be normally rated at 262 horsepower. Since superheaters are installed in the majority of waste-heat boilers, it is assumed that superheated steam could be used in the present instance and that the boiler is equipped with a superheater containing approximately 10 per cent of the boiler surface.

The exit gas temperature we would expect from this proposed boiler, utilizing the gas weights as given in Fig. 2 at

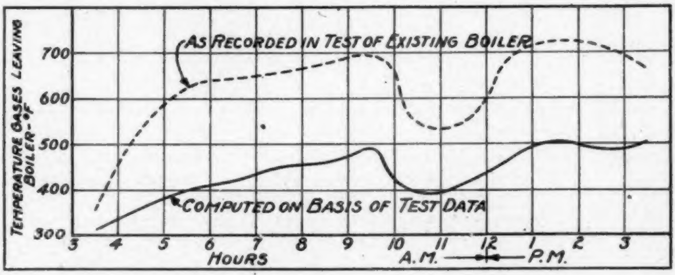


FIG. 4—EXIT-GAS TEMPERATURES

temperatures, as shown in Fig. 3, are shown in Fig. 4. The horsepower to be expected from this boiler and its superheater throughout the cycle is shown in Fig. 5. The expected output, as shown, is, of course, the result of a theoretical computation, but, as stated, our experience has given us almost absolute confidence in results so calculated.

If, then, we accept these results as even approximately correct, the advantages of the modern waste-heat boiler are obvious. We see such a design of boiler, containing, with its superheater, but 72 per cent of the surface of the boiler which is actually in operation and which may be taken as typical of waste-heat practice, developing from 14 to 55 per cent more horsepower at different portions of the cycle, and averaging for the two heats 16.5 per cent greater output. In terms of the normal rated capacities of the two boilers, the average

capacity developed for the two heats for the boiler installed is 53 per cent, while for the modern design of boiler this percentage of normal rated capacity would be 94 per cent.

It is true that the draft loss through the modern waste-heat boiler would be considerably in excess of that through the boiler installed and that the total draft suction required for the former

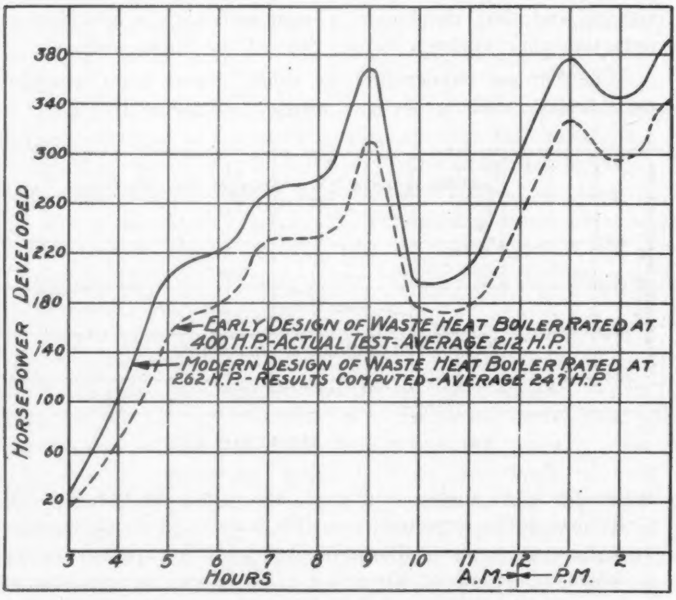


FIG. 5—HORSEPOWER DEVELOPED THROUGHOUT THE CYCLE

would necessitate the installation of an induced draft fan. Malleable furnaces, however, are all apparently operated with a slight pressure at the exit throat, and the power required to drive the fan is only that necessary to overcome the frictional resistance of the gases in their passage through the boiler. This amount of power, for the particular class of waste-heat work in question, is practically negligible.

The maximum draft suction at the outlet of the boiler installed was 0.79 inch during the test. The suction required

at the outlet of the proposed boiler would naturally be greatest when the greatest weight of gas was being handled and the greatest capacity was being developed. The suction necessary under such conditions would not be in excess of 2.0 inches, though, to allow a margin of safety, the fan installed would probably be designed to show 2.5 inches when handling the maximum gas weight. Even assuming the latter suction neces-

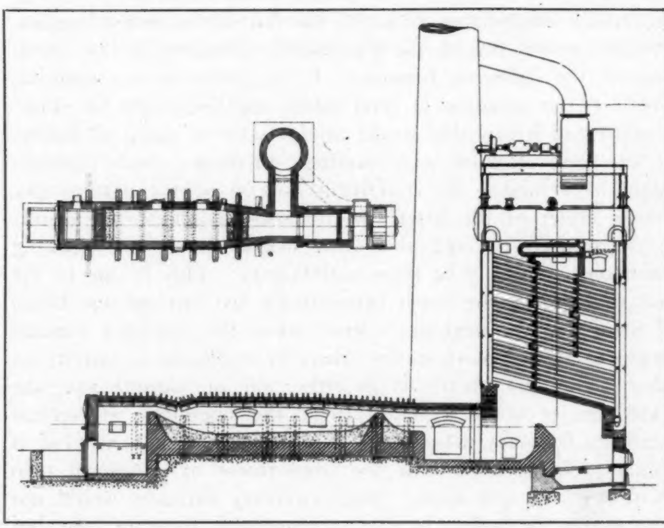


FIG. 6—GENERAL ARRANGEMENT OF WASTE-HEAT BOILER ATTACHED TO MALLEABLE FURNACE

sary and a fan efficiency of 50 per cent, which is certainly conservative, the indicated horsepower of the fan would be only 9.1. The smaller sizes of steam turbines have been developed to a stage where the steam consumption is as low as 33-36 pounds per indicated horsepower hour, but again, to be conservative, assume this rate to be 45 pounds. At such a rate, the gross power required to drive the fan in terms of boiler output would be 17.5 boiler horsepower, or approximately 5 per cent of the total. Since at least 85 per cent of this power may be regained through the use of the turbine exhaust

in a feed water heater, the net loss due to fan drive will be 2.6 boiler horsepower, or less than 0.75 per cent of the total boiler output.

Power Generated Will Vary

Fig. 5 indicates that the amount of power generated by an individual boiler will vary over a wide range at different portions of the complete cycle. Where a number of furnaces are equipped with waste-heat boilers, all of which are discharging into a common steam main, the fluctuation would unquestionably be less due to the unavoidable variation in the operation of the different furnaces. Even under such conditions, however, the variation in total steam supplied might be objectionable and it probably would be advisable to equip all boilers in this class of work with auxiliary furnaces. Such furnaces might be arranged for coal-firing, for oil or for natural gas. Where either of the latter two fuels are available, the results to be secured through their use would, from an operating standpoint, probably be more satisfactory. This is due to the fact that during the hours between the last tap and the hours of firing for the next day's heat, when the auxiliary furnace would be of the most service, there is ordinarily a scarcity of labor about the plant. With either oil or natural gas, the water tender could readily attend the operation of several auxiliary furnaces, whereas if the furnaces were hand-fired it would probably necessitate the employment of additional men to handle coal and ashes. Such auxiliary furnaces would not only enable the boilers to carry a reasonably constant load, but also would allow steam to be generated during periods in which the furnaces are not in operation.

Since no installations of the modern waste-heat boiler have been made with malleable furnaces, it is only possible to indicate how such a furnace might be so equipped. Fig. 6, however, will serve to illustrate such an installation. While this figure shows a coal-fired auxiliary furnace, a similar arrangement could be worked out for either oil or natural gas as the auxiliary fuel.

Only Reverberatory Furnaces Considered

In the foregoing discussion, only the reverberatory type of malleable furnace has been considered. A number of regenerative furnaces were observed in the investigation of the

subject and it would appear that the operation of such furnaces insofar as fuel and temperature conditions are concerned is analogous to that of an open-hearth steel furnace. The low gas weights available from the individual regenerative malleable furnaces, taken together with the low temperatures that accompany the use of the regenerative principle, would probably make the installation of waste-heat boilers on individual furnaces impracticable. It is possible that such an installation might be made with a number of furnaces operating on the same cycle, though this feature has not as yet been considered.

FIG. 1—WASTE-HEAT BOILER SHOWING AUXILIARY FIRE BOX AND MELTING FURNACES

Application of Waste-Heat Boilers to the Malleable Melting Furnace

By C. D. TOWNSEND, Danville, Ill.

After considerable investigation into the various kinds of boilers, including horizontal, marine, and others, we finally selected an upright water-tube boiler as the equipment best suited for the utilization of waste heat from melting furnaces. The fact that the floor space required was comparatively small was an important factor in determining the choice. The next question was size, and the results of our deliberations with the engineers were that it was preferable to have the boiler over-size rather than under-size. A 250-horsepower boiler was estimated to be of sufficient size, considering the grate area of the furnace; but because of what might be called a superheated gas after it has passed over a bath of molten metal, and because of the velocity of the same, greater capacity was deemed advisable and a 400-horsepower boiler was finally decided upon as being adequate for any emergency.

In order to utilize the waste gases from the furnace and get constant results from the boiler, and also to keep the boiler under steam pressure all the time, it is best to have two furnaces and an auxiliary fire-box connected with the boiler. By running the furnaces one at a time during the day, a full head of steam can be kept on the boiler, except for intervals during the time of charging the furnaces, and for a short period while the cold stock is being thoroughly heated. This takes care of all firing necessary on the boiler for at least 9 hours of the day. During the balance of the day the boiler can be kept under pressure with a slight amount of fire through the auxiliary fire-box. One furnace is operated while the other is being repaired; and then the order is reversed.

I have found also that the temperature control in the furnace and the efficiency of the boiler can be very materially aided by the addition of an induced-draft fan in the base of the stack. By operating this fan with a variable speed motor

or steam engine, the furnace draft can be regulated as desired. The use of the fan tends to hasten the time of melting and, due to the velocity with which the gases are drawn through the boiler, the efficiency is increased. We find that the temperature in the base of this stack is approximately 800 degrees Fahr., and that the temperature at the back bridge-wall of the furnace is about 2500 degrees Fahr. These figures show that a large volume of waste gas is used in making steam. We also find that with this equipment we evaporate approximately 246,000 pounds of water, and use in the auxiliary fire-box from one to three tons of coal per day, according to requirements.

Advantages of Auxiliary Fire-Box

As before stated, connecting two 20-ton furnaces to the auxiliary fire-box of the boiler insures a constant operation of the same while furnace repairs are being made. With the use of the auxiliary fire-box, the boiler is kept under pressure during the night and at other periods while the furnaces are not in operation. By keeping the boiler constantly under pressure and heat, the danger of breakdowns caused by contraction and expansion is minimized.

The boiler should be set as close as possible to the back bridge-wall of each furnace in order to utilize all the waste gas possible. This can be accomplished by setting the furnaces parallel to each other or at right angles to the boiler, which arrangement should be figured out to best suit local conditions. To take care of the tremendous amount of gases that pass through the boiler during the period of melting, it is advisable to set the boiler eccentric with the casing, leaving the greatest area on the front or steaming side of the boiler so that the extremely hot gases have a chance to rush up the front side and become effective nearer the top of the boiler. On the other hand, if the boiler tubes are set close to the casing, the intense gases and impinging flames will do most of their work on the tubes near the bottom of the boiler.

Ample Water Supply is Important

The water supply for a waste-heat boiler should be absolutely assured. It is best to have two independent sources of supply, since it is obvious that, if for any reason the water

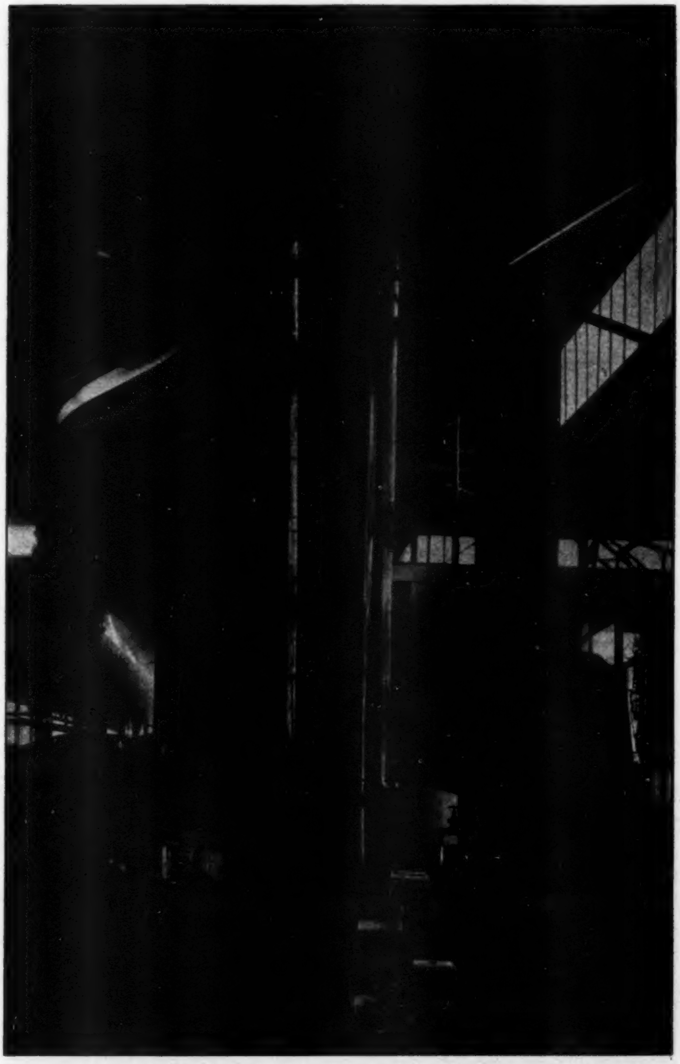


FIG. 2—WASTE-HEAT BOILER SHOWING THE INDUCED-DRAFT FAN

supply should fail, a heavy loss and probable calamity would result. To further insure continuous operation, all piping and valves should be extra heavy and erected with a great deal of care. In fact, expense should not be considered too largely in making the water and steam connections to a waste-heat boiler.

In the writer's opinion the most desirable use of a waste-heat boiler is when the full steam capacity of the boiler can be utilized. This can best be accomplished by using the waste-heat boiler in conjunction with a battery of hand-fired boilers, the steam pressure to be equalized and balanced by their use. In this way the waste-heat boiler serves as an auxiliary or a fluctuating source of steam supply to a boiler plant. If the steam line of a waste-heat boiler is connected directly into the steam log or header of the regular power-plant boilers, the hand-fired boilers can be run to the entire accommodation of the waste-heat boiler; that is, the hand-fired boilers can pick up the power load and carry it until the waste-heat boiler begins to come into service. Then the hand-fired boilers can be gradually slacked off and the fires banked, taking the full steam supply from the waste-heat boiler and thereby acting as a safety valve or regulator for it. It is apparent that in a waste-heat boiler there is no such thing as control of the steam supply. If all the steam that is made there cannot be used, it has to be wasted into the air.

A Word About the Care of the Boiler

A waste-heat boiler requires constant attention. It is most important to remember that the boiler is a fire-eater, and that to keep it on the ground the water supply must be *positive* and intelligently supplied. The boiler should be washed down and the tubes inspected for defects at least every three weeks, and the flues should be turbined, if necessary, not less than every six weeks. It is very important that treated water should be used to minimize the collection of boiler scale. Soot should be blown off the tubes at least three times a day. In fact, every possible care should be exercised to keep the tubes clean.

A 400-horsepower boiler connected with a 20-ton furnace operating at capacity will produce steam at the full capacity or a little in excess of the actual capacity of the boiler after the

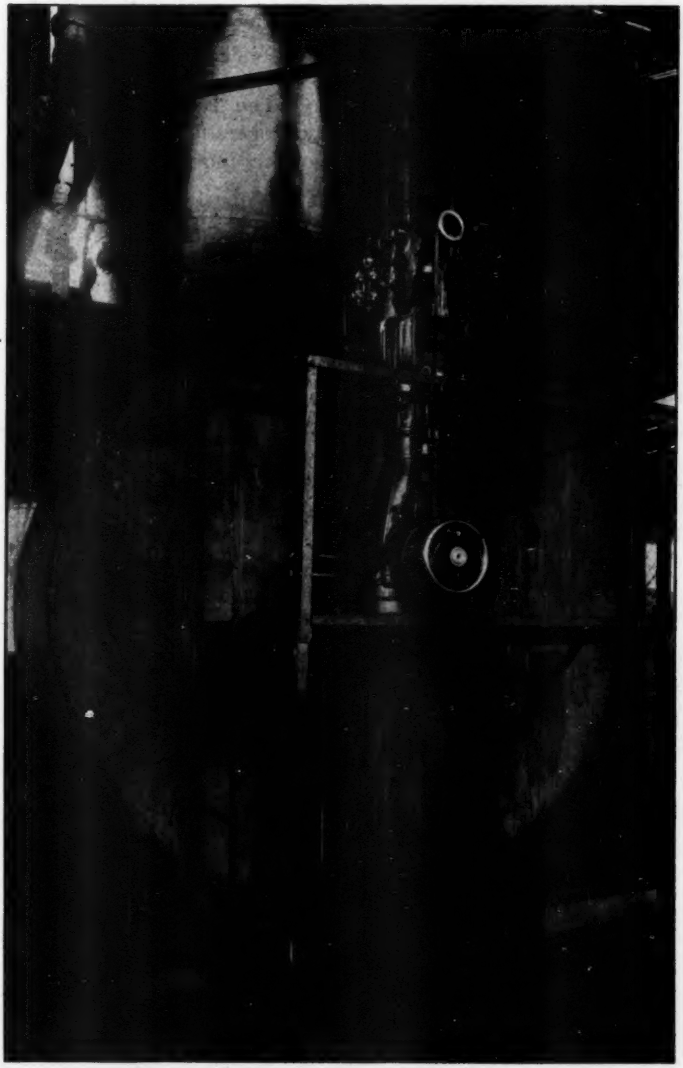


FIG. 3—A VIEW OF THE INDUCED-DRAFT FAN

iron has been reduced to a semifluid state or say for 8 to 9 hours per day. There is no effect noticeable on the furnace operation and, in fact, the furnaces are operated entirely in disregard to the boiler connection. The fuel ratios do not change; neither do the furnace firing operations. In fact, the entire furnace conditions are absolutely normal, and should proceed in utter disregard of the boiler.

Another Way to Use Waste Gases

Another method of utilizing waste-heat is to set a boiler of convenient size alongside the neck of the furnace. With a variable speed induced-draft fan at the base of the boiler stack, sufficient gas could be diverted into the boiler to heat water or produce steam, for various shop purposes, such as toilet uses, heating, etc.

How Malleable Iron Has Improved

By Enrique Touceda, Albany, N. Y.

I have been asked to prepare a short paper containing data that might assist in indicating the progress that has been made during the past few years in the improvement of malleable iron. It is believed this can best be done by tabulating the results of many hundreds of tests, starting from the time they began to be systematically conducted, presenting the averages in suitable form.

While prior to November, 1915, tensile test bars were sent me by the various concerns for whom I am consulting engineer, with frequency, but at odd intervals, it was not until the date referred to that it was decided to send on test bars daily which would fairly represent the product of each day's run.

Condensed Test Data

The record that will first be presented consists of the average ultimate strength and elongation of all bars received during the last two months of 1915; of all bars received during the whole of 1916; and of all bars received during the first five months of 1917.

To the end that you may obtain a clearer idea of what these tests indicate than if you were furnished simply with the average ultimate strength and elongation of the total number of bars received during these various periods, the results have been classified for your convenience into various grades, as shown in Table I. About 18 separate companies furnished these bars. Therefore, this data is not derived from tests of bars sent me by one or two concerns, but by a very significant number.

Looking over my records prior to the year 1914, in which there is abundant data, it was found that the average ultimate

strength and elongation would approximate about 38,000 pounds ultimate and 3.50 per cent elongation, respectively, though there are occasional instances of a 46,000 and 48,000 pounds ultimate with a 6 or 7 per cent elongation. On looking over these old records it is found that the test bars then submitted were of many different dimensions varying anywhere from ½ to 1 inch in diameter, while some were square and others rectangular in section. For this reason it is hardly possible to gather from this data any conclusions which can be compared accurately with the material that has passed through my hands since the beginning of 1914.

It will be noted in Table I that the proportion of the 1915 bars that failed to test up to 40,000 pounds was 5.80 per cent. In 1916 this ratio dropped to 2.57 per cent, and in 1917 to 1.68 per cent. Only 2.40 per cent of the bars exceeded 52,000 pounds per square inch ultimate in 1914, as against 16.76 in 1916, and 18.49 per cent in 1917. In 1914, 72.35 per cent of the bars exceeded 44,000 pounds per square inch ultimate, while in 1915, 86.42 per cent, and in 1917, 88.85 per cent exceeded that figure.

When the great difficulty that has been encountered by the manufacturer within the past six months in securing suitable coal and iron for his purpose is considered, the continued improvement in 1917 is certainly quite remarkable, as the handicap has been very large.

Another Important Fact

Another important fact that can be gathered from the data in Table I is one to which I called attention for the first time in my paper read at the Cleveland meeting last year, namely, that malleable iron of good quality is very different from other ferrous products in one particular, in that its elongation increases with its ultimate strength. Prior to the discovery of this fact it had invariably been assumed by all writers on this subject that the reverse was true.

While it is believed the foregoing data unmistakably demonstrate the fact that a healthy improvement in the quality of malleable iron has taken place within the past few years, they do not tell the whole story. One of the most serious short-

comings in malleable iron in the past has been its lack of uniformity. I consider the improvement that has been accomplished in this direction within the past few years to have much more far-reaching effect on the user of this metal, and to be of greater importance to him than the ability of the founder to obtain high strength and ductility. A high ultimate strength is not always specified owing to the belief on the part of some that when the ultimate strength is in the neighborhood of 42,000 pounds per square inch the machine tools can be speeded up to a considerably higher rate than is possible when working with metal having ultimate strengths around 48,000 to 50,000 pounds. This is a matter we will not discuss at the present time. If the individual record of many of the concerns, the results of whose physical tests are included in the data in Table I were examined, it would be found that they have made a practically uniform iron day in and day out for a period covering many months. Those whose showing is more erratic are improving in this particular from month to month.

The figures in the following tables, with one exception, were taken from the records of various different concerns covering iron made by them during June. These data demonstrate the uniformity in the quality of the material from many consecutive heats, illustrating the fact that the manufacturer of malleable iron who is well posted in malleable practice has full control of his product. The day of "hit or miss" has passed.

Record Elongation

The exception referred to is Table V, in which is recorded a run of 17 consecutive heats made during February, of this year. The average ultimate strength of the 17 bars is 52,784 pounds and the average elongation is 17.88 per cent, in spite of the fact that two of the bars contained a slight shrink which made them fail prematurely. In this set there are four bars with over 21 per cent elongation; one with 24.22 per cent; and one with 27.34 per cent. We have tested many bars within the past two years having an elongation as high as 24.00 per cent, but it is believed that 27.34 per cent is the record elongation of any malleable iron test bar ⅝-inch diameter yet produced. I might add that the reduction of area of this bar was 22.71 per

cent. The data in this table are furnished you because they clearly demonstrate what is possible to achieve along the line of quality and uniformity, the goal toward which we are aiming.

As I have made mention of no tensile tests aside from those made on the standard tensile test bar recommended by the A. S. T. M., it may be of interest to make record of the results of tests on bars with different-sized sections. Some four months ago six sets of bars cast from the same heat and of the following sizes were sent me:

Set No. 1, 12 bars, ⅝-inch diameter.
Set No. 2, 6 bars, ¾-inch diameter.
Set No. 3, 6 bars, ⅞-inch diameter.
Set No. 4, 6 bars, 1 -inch diameter.
Set No. 5, 6 bars, 1⅛-inch diameter.
Set No. 6, 6 bars, 1¼-inch diameter.

The *average* results are as follows:

Set Marked.	Ultimate strength lbs. per sq. in.	Elongation in per cent.
No. 1— ⅝-inch	52,141	15.62
No. 2— ¾-inch	48,062	10.54
No. 3— ⅞-inch	47,107	9.37
No. 4—1 -inch	47,317	11.56
No. 5—1⅛-inch	47,148	9.69
No. 6—1¼-inch	46,592	9.69

The foregoing table should serve as a complete answer to those who maintain that when malleable iron exceeds ⅝-inch it cannot be made strong or ductile. Our experience indicates that provided a casting is sound, high quality malleable iron can be produced today just as easily in sections around 1¼ inches thick as in the case of ⅝-inch sections. With increased thickness there naturally comes increased difficulty in removing all the shrinks, but we have within the past few years made great strides in the direction of securing perfect soundness in thick and intricately designed castings.

In short, great progress has been made in improving the physical properties of malleable iron solely and only because of a determination on the part of the manufacturers to systematically improve each step in the process. It is believed that the figures placed before you indicate that they have more than achieved a fair measure of success.

Table I

SUMMARY OF TESTS OF MALLEABLE IRON MADE IN 1915, 1916 AND 1917

	Per cent of bars under 40,000 lbs. ultimate.	Per cent of bars between 40,000 and 42,000 lbs. ultimate.	Per cent of bars between 42,000 and 44,000 lbs. ultimate.	Per cent of bars between 44,000 and 46,000 lbs. ultimate.	Per cent of bars between 46,000 and 48,000 lbs. ultimate.	Per cent of bars between 48,000 and 50,000 lbs. ultimate.	Per cent of bars between 50,000 and 52,000 lbs. ultimate.	Per cent of bars over 52,000 lbs. ult.
1915 *Covering last two months*								
Ave. ult. lbs. per sq. in....	5.80	9.47	12.38	21.44	21.15	16.22	11.05	2.49
Ave. Elong. per cent in 2 in...	4.91	6.55	7.38	8.87	9.47	10.17	11.27	13.38
1916 *Entire year*								
Ave. ult. lbs. per sq. in....	2.57	3.65	7.36	13.64	18.26	21.57	16.61	16.76
Ave. Elong. per cent in 2 in...	5.78	6.88	7.48	8.33	9.14	10.28	11.61	12.72
1917 *Covering first five months*								
Ave. ult. lbs. per sq. in....	1.68	2.75	6.72	12.83	20.53	20.22	16.78	18.49
Ave. Elong. per cent in 2 in...	5.78	7.37	8.20	8.72	10.11	11.51	12.97	14.94

All bars 5/8-inch diameter, and similar in all particulars to the tensile test bar recommended by the A. S. T. M. in its specifications for malleable iron.

Table II

RECORD OF ONE FOUNDRY DURING JUNE

Mark.	Ultimate strength lbs. per sq. in.	Elongation in per cent.
F2-5-10-1	46,032	8.59
F2-5-11-1	50,631	8.59
F2-5-11-2	46,700	8.59
F2-5-12-1	50,213	8.59
F2-5-12-2	46,917	7.03
F2-5-14-1	48,344	7.03
F2-5-14-2	47,324	6.25
F2-5-15-1	54,028	9.38
F2-5-15-2	46,540	8.59
F2-5-16-1	48,761	7.03
F2-5-16-2	51,012	9.38
F2-5-17-1	49,255	7.81
F2-5-17-2	47,706	7.81
F2-5-18-1	52,422	7.81
F2-5-18-2	50,733	9.38
F2-5-18-2	47,444	9.38

Table III

RECORD OF ANOTHER FOUNDRY DURING JUNE

Mark.	Ultimate strength lbs. per sq. in.	Elongation in per cent.
6-4-17	50,338	12.50
6-6-17	51,734	16.41
6-7-17	52,343	18.75
6-8-17	52,011	15.63
6-9-17	50,937	13.28
6-11-17	50,700	10.94
6-12-17	51,938	14.84
6-12-17	49,899	14.84
6-13-17	51,476	14.84
6-14-17	52,780	11.72
6-15-17	50,400	9.38

Table IV

RECORD OF A THIRD FOUNDRY DURING JUNE

Mark.	Ultimate strength lbs. per sq. in.	Elongation in per cent.
F1-AM-3-17	51,179	10.94
F1-PM-3-19	48,150	8.59
F1-AM-3-21	50,365	11.72
F1-PM-3-22	47,385	10.16
F1-AM-3-24	49,640	10.94
F1-PM-3-26	47,455	9.38
F1-AM-3-28	50,550	14.84
F1-PM-3-29	48,310	13.28
F1-AM-3-31	48,935	18.75
F1-PM-4-2	51,303	11.72
F1-AM-4-4	48,420	11.72
F1-PM-4-5	49,080	12.50
F1-AM-4-9	47,125	9.38
F1-PM-4-10	47,125	7.81
F1-AM-4-11	46,755	10.94
F1-PM-4-12	49,242	10.94
F2-PM-3-17	49,480	10.94
F2-AM-3-20	49,650	12.50
F2-PM-3-21	49,410	9.38
F2-AM-3-23	49,305	10.16
F2-PM-3-27	49,870	10.94
F2-PM-3-28	48,845	12.50
F2-AM-3-30	49,470	11.72
F2-PM-3-31	48,765	15.63

Table V

RECORD OF ONE FOUNDRY DURING FEBRUARY

Mark.	Ultimate strength lbs. per sq. in.	Elongation in per cent.
12-16-16	55,032	21.09
12-18-16	53,908	21.09
12-28-16	54,706	21.09
12-29-16	52,010	17.19
12-30-16	50,321	10.94*
1-2-17	54,867	17.19
1-3-17	54,283	13.28
1-4-17	53,537	21.09
1-5-17	55,804	27.34
1-6-17	51,380	11.72
1-8-17	51,978	24.22
1-9-17	52,506	17.97
1-10-17	52,477	17.19
1-11-17	50,097	14.06
1-12-17	49,910	12.50*
1-13-17	52,204	17.97
1-15-17	52,311	17.97

*Test bar broke in fillet.

Troubles Encountered in Machining Malleable Iron: Causes and Remedies

By A. T. Jeffery, Dayton, Ohio

The advent of the automobile with the subsequent use of large quantities of malleable castings in its construction opened up a new line of troubles for the malleable manufacturer, with all of the old troubles seriously magnified. High speed machinery puts malleable iron to a very severe test and the very best quality is not any too good for this purpose, and any product containing iron-carbide will be found unsatisfactory under these conditions.

White iron with its large percentage of iron-carbide will destroy the most costly tools just as quickly as it will the cheaper grades. In many cases it causes a delay of several hours, holding up the production of an expensive machine. Similar results, although perhaps to a lesser degree, will result from machining any iron containing even a small percentage of combined carbon. Iron with a pearlitic rim will spring machine tools causing them to give oversize dimensions, making necessary a second operation. Iron with a thick decarbonized rim will clog the teeth of milling cutters and push ahead of a lathe tool that is properly ground for machining ordinary malleable.

Five Varieties Cause Trouble

There are five distinct varieties of iron from which one or more of these complaints may arise. They include pure, hard white iron, under-annealed iron, iron cooled too quickly, burned iron and iron that is sometimes called hard but is really tough and stringy.

Pure, hard white iron cannot get into the machine shop except through carelessness. It is very easily recognized by an expert, although to the uninitiated and under ordinary conditions it may be confused with under-annealed iron. The only

remedy for pure white iron in the machine shop is care that hard and soft iron shall not be allowed to come in contact with each other or cross each other's path in passing from one department to another.

Under-annealed iron may be in two states, first as shown in Fig. 1, not affected by the heat of the annealing furnace. In this condition it has practically the same qualities as pure white iron except that initial strains due to cooling from the molten state have been removed. The second state is shown by Fig. 2. This iron will give all kinds of trouble in the machine shop. It will wear machine tools very rapidly, cause them to heat and will also strain the jigs and chucks unless they are massive and designed with a large factor of safety. It will show a black fracture when broken and cannot be detected except by chemical or preferably by microscopic analysis. It has little ductility and only slight resistance to shock.

Either state of under-annealed iron is caused by lack of proper heat treatment. Annealing ovens with bad circulation, too large annealing pots or lack of proper knowledge or facilities for reading temperatures are the usual underlying causes. They are to be remedied by a scientific study of draft conditions, size and spacing of pots and the installation of adequate and reliable pyrometers. Large pots jammed tightly together forming nearly a solid mass of iron can heat only by the conduction of heat from the exposed tops, which must be at a considerably higher temperature than is necessary to anneal properly, in order to produce a flow of heat to the less exposed parts. There is thus a tendency toward false pyrometer readings of the actual temperature of the coldest part of the oven, the inside of the pot. There will be very little circulation of hot gases around the pots and they will go to the outlet that offers the least resistance and is the most direct. The outlets for gases should be so placed that the gases will be forced to come in contact with all parts of the oven and the intensity of the draft should be measured and gaged to insure a proper quantity of heat reaching every pot.

Test Lugs Are Useful

As a check on the efficiency of the heat treatment, test lugs should be placed on all castings of sufficient size to warrant it

and two or more on extremely large ones. They should be broken by hammering and the quality of the iron determined. In the case of small castings at least one should be broken from the center of the bottom of each pot. There will be no trouble from under-annealed iron in the machine shop if these suggestions and precautions are carefully heeded.

One of the most aggravating troubles for the machinist is caused from iron with a pearlitic rim, as shown in Fig. 3. It will lead the machinist to register a vigorous kick and yet under ordinary tests the cause cannot be detected and the average observer will pronounce the iron good. The iron very likely will bend well when hammered and the fracture will be black except for the usual compression edge seen in all black heart malleable. Such iron, however, will wear and spring the machinist's tools and his verdict will be "hard iron". When subjected to the microscopic test, however, by a trained observer the trouble is easily determined; usually it is caused by too quick cooling. This has not caused it to be entirely returned to the white iron state and will not unless the cooling is done very quickly.

Quick cooling is nearly always the result of carelessness or lack of knowledge of the consequences. Iron cooled faster than 20 degrees per hour will be in the danger zone. Bad dampers controlling the draft, fire and ash pit doors left open, cracked or leaky walls and removing the doors from the oven too soon will cause this trouble. A crack in the ash pit wall where the fire is above the floor line of the oven will furnish enough cold air to chill adjacent pots. The remedy is obvious. First, however, an educational program must be instituted, because workmen in charge of the annealing generally do not understand the detrimental features resulting from little acts of carelessness in looking after this part of their work. They are in the habit of judging from fracture and therefore do not detect anything serious when a piece of iron cooled too quickly is broken.

Burned iron affects the machinist in about the same manner as hard or unannealed iron. It is perhaps a little more easily drilled and with very powerful tools may be machined. However, what has been said about hard iron will fit here also.

Fortunately for the malleable manufacturer burned iron is rare except as it creeps in at the tail end of a cast unobserved to be discovered later and laid at the door of the annealing oven when its identity is not fully ferreted out and properly accounted for. I am considering here as burned that iron in which certain elements have been too far removed to allow the breaking up of the iron carbide in the annealing furnaces. Except in very rare cases it is not seriously damaged as far as its properties are concerned, although in those rare cases it will take on a honeycombed appearance and become absolutely useless except for remelting.

Effect of Low Silicon

If either the carbon or silicon is too much reduced in the melting furnace, iron will be produced that cannot be annealed, under ordinary conditions. Iron too low in silicon can be obtained by error in calculating the mixture, mistake in the chemical laboratory analyzing the pig iron or by excessive oxidation in the melting furnace. Manufacturers using a low-silicon, high-carbon mixture are most liable to encounter this condition. Error in the calculation of the mixture needs no comment; it is the result of carelessness or may be due to entrusting this work to an incompetent man or one who has not had educational opportunities.

Bad chemical analyses may often be laid at the door of the blast furnace people, some of whom have had the honesty to admit that their analyses may be as much as 20 per cent off either way. The best way to eliminate this evil is to analyze each car of iron and use more than one car or kind of pig iron in the mixture, trusting in the law of averages to keep within proper limits. A furnace that is oxidizing rapidly will finish the job if the conditions mentioned are not watched; a sleepy fireman with holes in his fire or too much blast coupled with bad furnace practice will increase the danger. A well practiced eye aided with long experience in taking tests under standard conditions will help materially when low silicon is encountered because the eye will detect the trouble and our old friend ferro-silicon may be added to bring up the silicon content.

Carbon plays just as important a part as silicon and may or may not be low enough to give trouble when the silicon is

low. When one considers that the best malleable is made with carbon hovering near 2.30 per cent and that 2.20 per cent is decidedly in the danger zone with ordinary malleable mixtures, also that pig iron may vary as much as 1 per cent in carbon, then one must prepare for trouble if he attempts to make low-carbon iron in large quantities with several furnaces running. Carbon is subject to about the same amount of oxidation as silicon under the same conditions, the only difference being that it cannot be replaced as readily. Therefore it behooves the most of us to play safe on carbon, at the same time protecting the machine shop from hard iron and also from semi-gray iron.

Tough Iron is Troublesome

Last but not least of the sources of complaint from the machine shop is iron that bears the name of being hard but really is too soft and tough to machine readily. Most machine hands have had trouble at one time or another machining very good wrought iron. It pushes ahead of the tool and causes excessive chattering and wear, making necessary an extra cut, and in case the machine tool is weak it will jump out of the holding fixture and seriously strain the machine. The outside rim of extra-good malleable resembles the best wrought iron and closely rivals it all through the section. Its chemical make-up as far as iron is concerned is the same except that the particles of slag worked-in in wrought iron are replaced with particles of temper-carbon in malleable iron. (See Fig. 7.)

Manufacturers of malleable iron should refuse to take this kind of iron back as foundry scrap. They should demand that the user provide sufficiently strong machine tools, run at such speeds as to readily care for this iron. The writer had occasion recently to inspect castings returned for being hard that had been drilled in several places and tapped in others without any apparent difficulty but upon boring a 12-inch dimension, the tool had evidently refused to cut. Microscopic analysis showed good, normal malleable, but upon investigation it was determined that the machining was done on an ordinary drill-press using a boring bar in place of a drill running at high speed. The best of high-speed steel was used. On the other hand, a certain well-known manufacturer uses such sturdy

machines that a chattering tool is rarely heard in the entire shop and when a casting is returned for being hard there is no doubt about the fact that it is hard. Of course, these are two extreme cases, but they serve to illustrate my point.

The malleable manufacturer can eliminate all trouble from this source by making relatively high-carbon iron, annealing it in nearly inert packing, producing iron that perhaps will pass as malleable. But at the same time he will be wandering away from the best practice and will not add to the reputation of the industry, which has suffered in the past from just such weak-hearted practice.

Summary

In summarizing, it may be said that the fundamental or underlying cause of trouble with malleable iron in the machine shop is generally due to a lack of scientific study of the material in question along practical lines and to the lack of active co-operation by the users of malleable iron. Designing engineers have neglected to familiarize themselves with the properties and peculiarities of malleable iron due largely to the meager amount of authoritative information in print, and their unwillingness to accept the statements of men who are well informed but are perhaps unable to express themselves fluently and who are the operative heads of our best malleable foundries. In many instances bad designs are changed with reluctance, although the engineer is becoming more alive every day to the advantage and necessity of close co-operation with the practical man in the foundry. As in other spheres, therefore, *co-operation* should be our watchword and with intelligent effort and hearty co-operation between producer and user, most of our troubles will disappear.

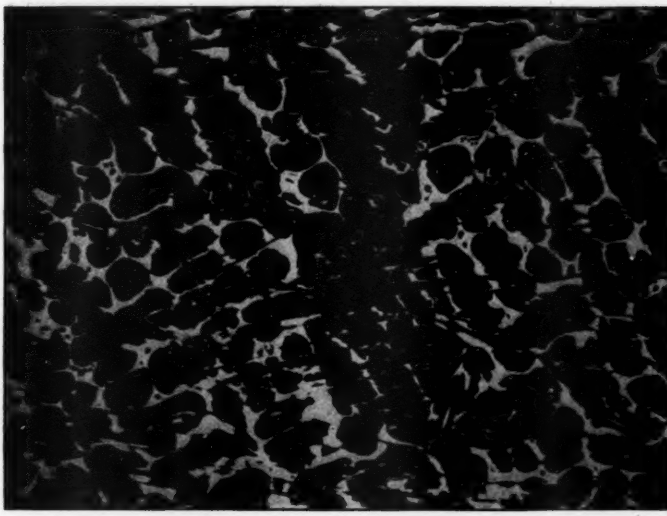


FIG. 1—MICROGRAPH OF WHITE IRON SHOWING FREE CEMENTITE IN WHITE AREA—DARK AREA IS PEARLITE

FIG. 2—UNDER-ANNEALED IRON SHOWING SOME FREE CEMENTITE

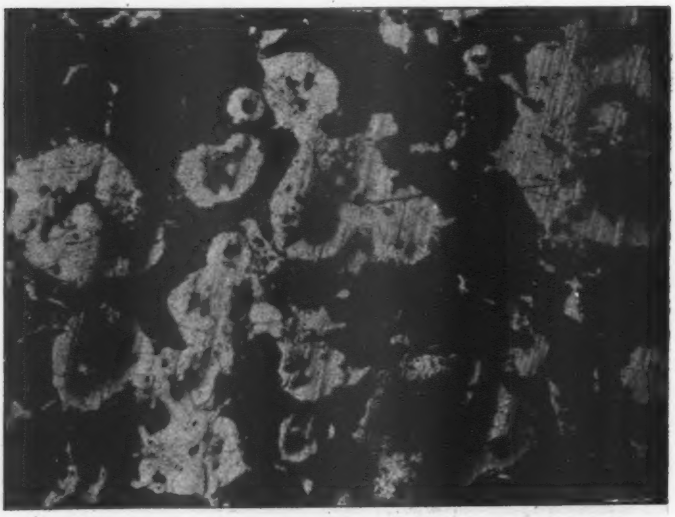


FIG. 3—IRON COOLED TOO QUICKLY, SHOWING PEARLITE IN DARK AREAS

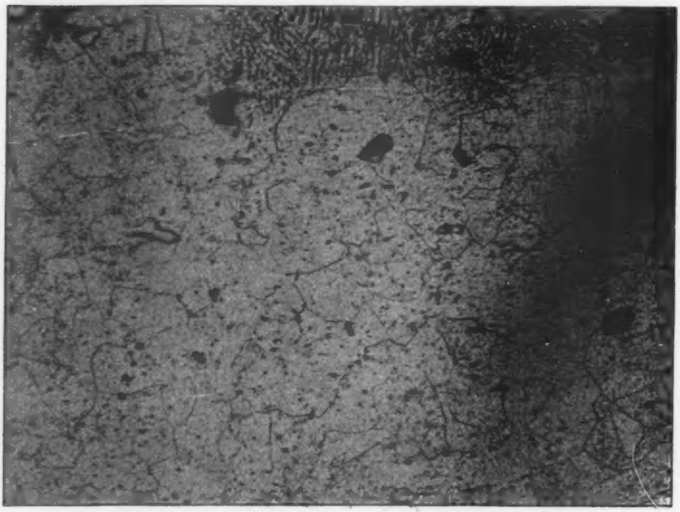


FIG. 4—DECARBONIZED RIM

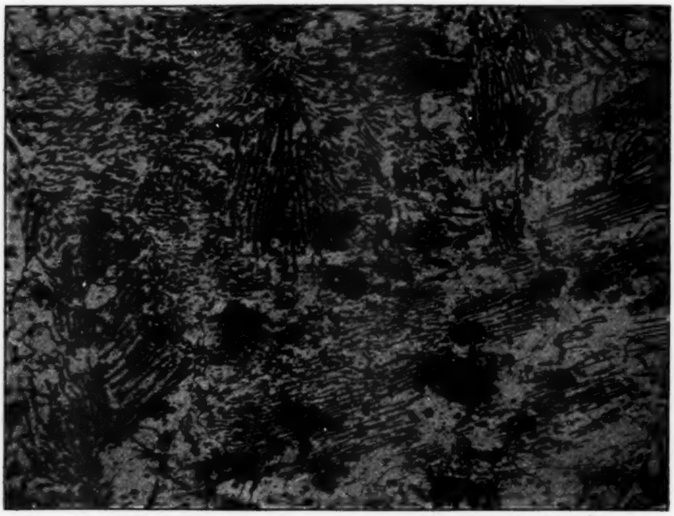


FIG. 5—FRAME OF PEARLITE

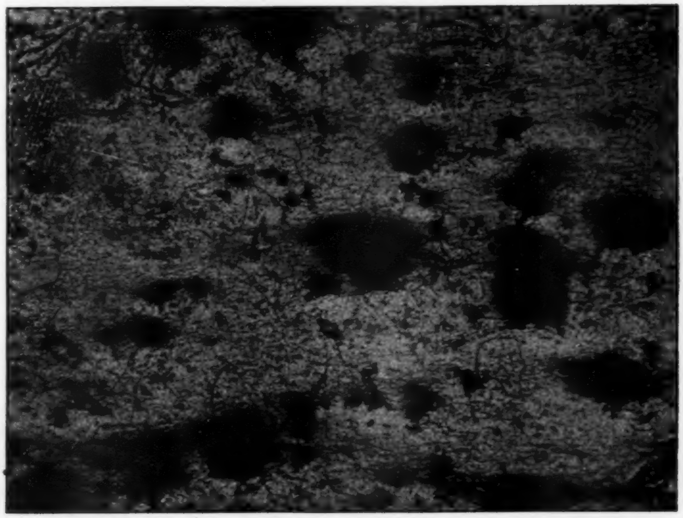


FIG. 6—CORE INSIDE OF FRAME

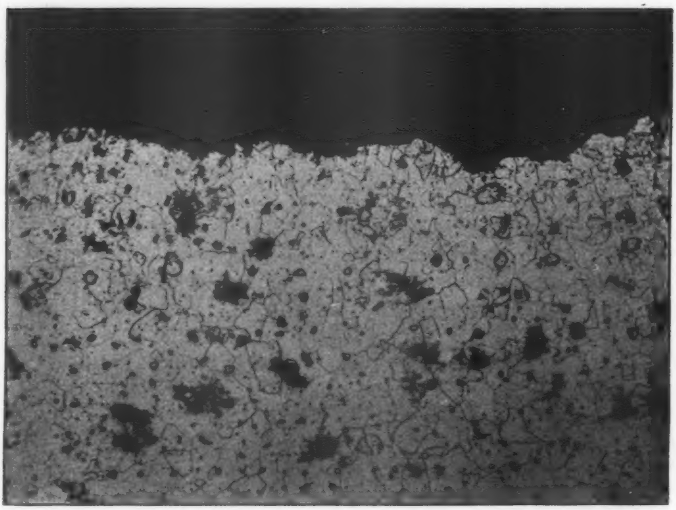


FIG. 7—DECARBONIZED RIM OF TOUGH MALLEABLE IRON

Discussion

Mr. S. Griswold Flagg, III:—I think one of the most interesting features that Mr. Jeffery brought out is where he talks about the method by which that casting with the 12-inch dimension was cut, and the fact that they went back to the user of the casting and found out that they were not using a proper machine tool.

Mr. C. H. Gale:—I have had considerable experience in the last few years of the same nature. A few of our customers don't want a strong, tough product. They want an iron that will machine easily and readily. They want an iron that will machine more like malleable pipe fittings.

We have had a number of castings of various kinds returned with the complaint that they were hard. We found in many cases, however, that they were not hard. Instead the

iron was exceedingly soft, tough iron. Under a cutting tool such iron would push up ahead of the tool and come out in a long curl.

MR. WOOD:—I would like to ask if it is known what is the ultimate speed at which we might expect to machine malleable castings?

MR. ENRIQUE TOUCEDA:—I have paid quite a little attention to this proposition of cutting speed. I have spent considerable time in machine shops where gears and automobile castings are finished. Most of these shops have machine tools speeded up to almost brass speed, 150 feet per minute. They get into trouble when they run to 175 feet. If they attempt much more, I mean 200, except with very, very light feed, why, then, of course, it is disastrous. Some are running 150 feet per minute.

MR. J. B. DEISHER:—On one page the author says, "Iron cooled faster than 20 degrees per hour will be in the danger zone." I would like to ask how low the temperature would have to run before that rate of cooling could be increased without danger of recombining carbon?

MR. ENRIQUE TOUCEDA:—There is always danger of carbon recombining unless the cooling is conducted very slowly from temperature. It ought not to cool any faster than about seven or eight degrees per hour, if possible for 12 or 15 hours, and then at about 10 degrees per hour for the next 15 hours. In other words, you should come down to about 1250 degrees anyhow with the greatest possible degree of slowness.

THE CHAIRMAN, MR. J. P. PERO:—Does that answer your question?

MR. J. B. DEISHER:—Yes; but after the temperature has come down to 1250 degrees, will an increased rate of cooling make the iron harder?

MR. ENRIQUE TOUCEDA:—There results no structural change at all, but there may be physical damage due to the introduction of internal strains which may affect the casting. On heating annealed malleable iron the carbon starts to recombine at about 1375 degrees Fahr.

The Application of Pulverized Coal to Malleable Melting Furnaces

By JOSEPH HARRINGTON, Chicago.

Melting malleable iron with powdered coal as a fuel must still be considered in the experimental stage. The assurance that its advocates feel comes from an analysis of the requirements for melting and the definitely defined results that can be obtained with this fuel in securing controllable temperatures. In but one instance known to the writer has malleable iron been melted with powdered coal on a commercial scale, and this experiment was so brief that the only practical effect was to supply the observers with a fund of optimism and a feeling of certainty that had the work been continued, economical operation would have been effected. My analysis, therefore, must necessarily be more or less along the lines of theory, but I hope thereby to bring out in discussion such actual experiences as have been obtained, confirming or rejecting the theories advanced in this paper.

A Diversity of Opinion

In conversations with foundrymen I have developed a considerable diversity of opinion as to the temperatures which actually obtain in the malleable furnace. This experience does not differ in any way from that which one develops when the matter of high temperature in steam boiler furnaces is under discussion. It is not the simplest matter to determine temperatures above the range of the thermo-electric couple. Nominally at least, the base metal couple can be utilized up to 2400 degrees Fahr., but rapid deterioration takes place at these temperatures and the reading to a considerable degree is unreliable. The use of the radiation or optical pyrometer is also uncertain to a certain extent, because of the ease with which the instrument may be put out of adjustment and the care that must be exer-

cised in focusing on a solid body without a gas screen to affect the intensity of radiation. When a good instrument is properly used the readings are correct, and the writer has developed temperatures in this manner up to 3000 degrees. Under these conditions the amount of excess air supplied was cut down to near the limit, the carbon-dioxide resulting being about 16 per cent.

Temperature is also affected by the size and proportions of the furnace, so that a proper design will enable the engineer to secure temperatures which are sufficiently high and at the same time practical in the matter of brickwork maintenance.

The iron charge melts at various temperatures, ranging from 2200 degrees to probably as high as 2600 degrees, so that it is necessary to obtain at least the latter temperature for the prompt and economical production of fluid iron. This can easily be obtained with pulverized coal, especially if it is introduced as in a bunsen burner, which provides the elements in proper proportion within the fuel jet itself. The question of proper mixing of the fuel with the air for its combustion is absolutely vital, and in this process particular care must be taken that all of the elements are under control. Both the coal and the air must be introduced in such a manner that the character of the flame can be changed at will in accordance with the requirements of the charge at its various stages of heating and fusing.

Charge Should be Heated Rapidly

During the early stages of heating, the charge is cold and should be brought up to melting temperature as soon as possible consistent with the proper soaking effect. The charge as a whole should come to its melting temperature with a reasonable degree of uniformity, so the various ingredients will not be melted at different times and enter the bath unmixed. The time element in this introductory period is one that affects the fuel economy only. The curve of temperature rise should be as steep as possible, because this is usually a period when the combustion is least complete and the loss consequently greatest. With powdered coal I venture to state the firing end of the furnace can be brought to a high heat within an hour, even though the furnace is cold to start with. With hand firing

this period is often several hours long. Herein we see the first evidence of economy with this fuel.

The second period is one in which both fuel economy and effect on the charge are to be considered. After the iron reaches its melting point the charge begins to subside and becomes liquid. This is a period when it is most probable the loss of the valuable ingredients in the iron takes place. We have present the necessary temperature in both the metal and the oxygen, together with an intimate mixture of the two which practically necessitates the oxidation of an appreciable percentage of carbon, manganese and silicon in the charge. Not only do these elements burn out, but other and less desirable elements may increase if the contact is unduly prolonged. The presence of sulphur in the furnace gases is one that has been commented upon in many different ways. Foundrymen almost always go to the expense and trouble of buying a special grade of coal which is low in sulphur on the theory that this harmful element should be kept as low as possible for the sake of its effect on the product. At the same time I have heard it emphatically stated that some of the best physical tests were obtained from iron which analyzed high in sulphur, so that it is not definitely defined in my own mind just what weight the amount of sulphur in the coal should have in such a discussion.

Not Like Other Fuels

In any event, as has been so clearly stated by Mr. Spring of the Crane Co., the burning out of certain elements may be serious and the melting of the charge should therefore be effected as rapidly as possible. The intense and sustained temperatures which can be produced with powdered coal would certainly lead to the belief that the desirable conditions for quick melting could readily be obtained. It must always be borne in mind that the fuel we have under discussion is nothing like solid fuel. We introduce the entire body of fuel directly into the chamber to be heated and at the same time it is of such a nature that the mixture is most intimate and the combustion most complete. Any proportion of air and fuel may be introduced, so that the character of the resultant flame may be nicely adjusted to the requirements of the melting process.

This is in very sharp contrast to the average hand fired furnace wherein the blast has to be shut off periodically while the door is opened for firing. The production of heat during this time is suddenly lowered, and the temperature of the furnace correspondingly drops. After the fresh charge has begun to burn freely, the temperature mounts to a point slightly higher than before and about the time the fire is in its best condition, the blast is again shut off and the operation is repeated.

The temperature curve is therefore one of alternate risings and fallings, making it like a saw-tooth. This, of course, is not strictly the case with the relatively few natural draft furnaces, but the effect of the introduction of the fresh fuel is the same. The fire has to be continually raked, and the production of gas necessarily varies. Not only does it vary, but it is under very little control, the only effect which the average furnaceman desires being the production of the required temperature. To this end he sacrifices everything else and under unfavorable conditions he may fire several hours just as hard as possible before the charge is properly heated.

More Hard Firing

After the iron has all liquified and becomes covered with a layer of slag, further hard firing must be resorted to in order to produce a temperature high enough to render the iron sufficiently fluid for its purpose. With the iron thus protected from the effect of the furnace gases the presence of more or less oxygen is a matter of indifference so far as the iron itself is concerned. Under these conditions, with powdered coal the excess air can be proportioned to produce the most intense temperatures, and I do not hesitate to state that flame temperatures well in excess of 3000 degrees may thus be created. A peculiar effect which accompanies a powdered coal flame in proper condition is the absence of the heavy rolling opaque flame which is so noticeable under ordinary conditions. It was found after many experiments with fuel oil that the non-luminous flame was the hottest. This, of course, is similar to the gas flame of the bunsen burner as compared to the fish tail burner. With powdered coal the condition chemically is similar, but on account of this fuel having a high percentage of fixed car-

bon in it, absence of luminosity cannot be obtained. At the same time the extent of the flame can be controlled so that complete combustion will take place within five or six feet of the burner even when this burner is delivering 500 or 600 pounds of coal per hour. The effect of the direct contact of such a flame with any object is extremely destructive. It is possible to melt a clay fire-brick almost as readily as a piece of iron after it is placed in exactly the right relation to the jet. The point of most intense temperature is just about at the end of the flame, and one can readily appreciate the reason why a pile of iron must liquify promptly when one considers that the flame temperature is perhaps as high as 3500 to 4000 degrees.

Effect on Furnace Lining

Another serious question which arises in this connection is the effect upon the refractory lining of the furnace. This should be divided into two parts for discussion. First, the effect on the brick of the temperature alone, and second, the fluxing effect due to the chemical action between the bath or the slag and the brick which forms the furnace walls.

So far as the first is concerned I would not consider that the deterioration of the refractories would be any greater than with ordinary methods of firing. In the first place the powdered coal jet does not impinge directly upon any brick work, and there need be, therefore, no blow pipe action whatsoever. The controllability of the flame is such that just the right furnace temperature may be secured and I do not believe it is a necessary consequence that the high temperature jet will result in any greater fusing of the brickwork than now obtains with the long continued hand firing. A good brick should be able to withstand 2800 degrees indefinitely, and 3000 degrees for moderate periods. I doubt if these temperatures are often reached in the malleable furnace.

The second consideration of the firing effect is more serious, but is one which I feel can be kept under control. The chemical analysis of furnace slag does not differ in quality from the analysis of ash from powdered coal. Ash analyses show a wide range in the percentages of the various ingredients but seldom any great diversity in the ingredients themselves.

These are the oxides of silicon, aluminum, iron, manganese and calcium, which correspond to the elements appearing in the malleable furnace slag. The addition, therefore, of melted coal ash to the bath does not alter anything except the range of its chemical constituents. The effect on the furnace lining may be altered in case the addition of the coal ash should bring some one element greatly in excess of the others, but I can see no reason why the addition of these elements should make the character of the slag seriously different. It would even be possible to introduce a certain amount of lime for instance, should it be necessary to keep the slag basic. In fact almost any such element could be introduced with the coal and very intimately mixed with it, so that the resultant slag could be readily controlled, both as to chemical analysis and fluidity. I cannot but feel, therefore, that fears regarding the destruction of the furnace sidewalls are based on considerations which will disappear when the matter is more fully studied.

Less Carbon Burned Out

All the evidence which I have been able to obtain from the brief practical experience with this fuel in this service, is that there was an actual diminution in the burning out of carbon to the extent of some 2 to 5 per cent, rendering it necessary to decrease the amount of new pig in the charge to that extent in order that the character of the iron should be the same. This experience is much the same as that which has been accepted by steel manufacturers in their experience with this fuel in heating steel. With fuel oil in steel heating service, we find from 6 to 8 per cent of excess oxygen in the gases, the actual oxidation of the iron due to the heating in the furnace being about 4 per cent. With powdered coal in the same furnace the amount of excess air is reduced to between 2 and 3 per cent, so that the amount of oxygen actually present in the furnace gases is less than one-half and the oxidation of the metal is substantially reduced. Observations indicate that this reduction may be as great as 50 per cent.

What is true when iron is only heated to rolling temperature should most certainly be true when actually melted, so that

the grounds for believing in a reduction of oxidation are certainly good.

The situation commercially at this moment is rather peculiar. Almost without exception foundrymen will admit all of the foregoing, and the figures which I have prepared in a number of cases showing the probable savings, have remained undisputed. These savings are as much as 100 per cent per annum, and yet the entire industry seems to be waiting for the other fellow to do it first. It is certainly a case where precedent is strong, and the reluctance of the foundrymen of this country to take the first step will probably be balanced by their eagerness to fall in line just as soon as the pioneer has completed his installation.

Discussion

MR. S. GRISWOLD FLAGG, III:—It has occurred to me to raise the question of what becomes of the dust. I mean, the fine ash. Would the fine ash from the natural draft furnace spread over the neighborhood? Would it be objectionable in a closely built-up section?

MR. W. R. BEAN:—Not more so, I believe, than the smoke; in fact, not as much. The city authorities of Chicago watched very closely the work that was done at Deering Works with pulverized coal in comparison with the hand-fired furnaces, and I have been told, reported very favorably.

MR. S. GRISWOLD FLAGG, III:—Naturally the dust would carry further than the cinder.

MR. W. R. BEAN:—There is not very much dust that passes through the stack. The greater part of the dust fuses and deposits before reaching the top of the ordinary malleable furnace stack.

MR. S. GRISWOLD FLAGG, III:—Then you have to skim more.

MR. W. R. BEAN:—Slightly. There are 1600 pounds of ash approximately, in melting a 20-ton heat. That is one of the

reasons why I favor firing into a combustion chamber preliminary to the melting chamber. In that case, you will deposit the greater part of the ash as slag in the firebox, whereas, when firing direct onto the charge you deposit over it in the melting chamber and at the base of your stack.

Mr. S. Griswold Flagg, III:—I remember going through the International Harvester plant when they had the annealing done many years ago with pulverized coal. They had great big deposits of very fine ash.

Mr. W. R. Bean:—Yes, inside the furnace chamber. That applies wherever pulverized coal is used in annealing. The annealing process is another subject, but the advantages are apparent. Those who have gone into it are pushing it.

As to temperatures, recently I have taken some figures in as accurate a way as possible. I have taken melting furnace temperatures with the Ferry radiation pyrometer, both natural draft and hand-fired, getting temperatures directly in front of the bridge wall varying between 2800 and 2900, 2950 degrees. I have never recorded a 3000-degree temperature in the malleable melting furnace. I have taken temperatures with the highest grade of electro-thermo-couple units and Le Chattelier air pyrometer, through the side wall and obtained the same temperatures, 2800 to 2950 degrees, and the latter I think is the highest I have ever taken. Incidentally, I have taken temperatures in the stack base of 2500 degrees, and that is where a great big part of the fuel is wasted.

The effect of oxidization and the time during your heat in which the charge melts down is a most interesting proposition. I used to feel that oxidation takes place after melting down and after skimming. That is not a fact. The reduction of silicon and manganese is almost entirely confined to the period of melting down when the charge is piled up in the furnace. The flame is passing through it, around it, and as the iron melts and trickles down, it goes through an oxidizing atmosphere and flame condition which takes out the silicon and manganese and puts in the sulphur. After melting down there is comparatively little change in the silicon and manganese but a great change in the carbon content.

Mr. S. Griswold Flagg, III:—Do I understand, Mr. Bean, that you burn out the carbon content?

Mr. W. R. Bean:—You burn out the silicon and manganese, principally in the period of melting down the charge.

Mr. S. Griswold Flagg, III:—Then you burn out the carbon after you have melted down?

Mr. W. R. Bean:—More than the silicon and manganese, after you have melted down.

Mr. S. Griswold Flagg, III:—It must be due to something else. I can't imagine burning out carbon and not burning out silicon and manganese. Is it due to a mixture of material?

Mr. W. R. Bean:—If anyone wishes to check it up, all he has to do is take samples about every 15 minutes after the heat is melted down and analyze those for the different elements. Then you get the whole story.

Comparative Carbon Losses in Malleable Iron Annealing by Muffle and Pot Oven Methods

By Joseph B. Deisher, Rochester, N. Y.

We know that carbon in any ferrous metal must exist in the form of combined carbon or graphitic carbon or both. To go a step farther, we must admit that, after all, it is principally the proportion and condition of the carbon present which determines in what class we shall ultimately define such metal—that is, whether we shall call it wrought iron, steel, malleable iron, or gray iron. Therefore, it seems hardly necessary to state that the vital importance of carbon in malleable iron cannot be over-estimated. However, the limitation of my subject does not invite any prolonged discussion of this element except as it is affected by the annealing process.

Combined carbon represents a condition where practically all of the carbon present has, due to certain laws of metallurgy, gone into solid solution with iron, forming iron carbide, or, in malleable practice, what is generally known as hard iron. Had the greater part of the carbon not gone into solid solution, an ordinary gray iron casting would have been the result, representing a composition of free graphite, combined carbon and pure iron. Here, the carbon would largely exist as graphitic carbon. The former represents a proper composition for annealing, while the latter does not.

Then, we may consider that the annealing of malleable cast iron consists of heating a hard iron casting of the proper chemical composition to a degree of temperature where practically all of the iron carbide is dissolved from solid solution, without subsequent fusion, after which the casting is allowed to cool to handling temperature (150 to 300 degrees, Fahr.)

The term "solid-solution" is, for the sake of practical simplicity, used to define the state of combined carbon, which is in reality a chemical compound of iron and carbon in solidification, usually referred to as cementite or FeC_3. Apology is made for the incorrect appropriation of this term from a strictly technical standpoint.

under conditions that will permit the carbon to precipitate as minute graphite deposits in a texture of practically pure iron. In other words, the annealing process is simply a precipitation or conversion of carbon which had previously been driven into solid solution with iron; but, this conversion is most always accompanied by a loss of carbon, and it is this removal of carbon that later on we are to discuss.

As briefly outlined herein, the annealing process seems very simple; yet, there are many conditions that may interfere with the perfect conversion of the carbon, some of which we will discuss in the following order: Hard iron composition; annealing temperatures; time required to dissolve iron carbide; rate of cooling; and removal of carbon.

Hard Iron Composition

In the first place, the analyses of the hard iron composition must, of course, come within certain specified or ratio limits; else, the iron carbide will not completely dissolve under ordinary annealing temperatures. To establish these limits is not the purpose of this paper. For the sake of brevity, we must assume that they are known. However, it might be appropriate here to state that a hard iron composition figured on the silicon alone is no better than guess work, so far as obtaining uniform physical results in the annealed product is concerned. In fact, the most uniform results can obtain only where we know with some degree of accuracy the total carbon content in the hard iron; and such knowledge is not readily available without the total carbon analyses of the pig iron, which, due to its high and variable carbon content, determines the percentage of the various grades of scrap material that can be carried in the melting mixture. The blast furnace people are reluctant to furnish or guarantee the carbon analyses of pig iron, which is a matter of such vital importance to the successful production of high-grade malleable iron castings that I hope it will merit thorough investigation by a competent committee.

Annealing Temperatures

In the matter of annealing temperatures for malleable cast iron, much depends upon the chemical composition of the hard iron. Ordinarily, the iron carbide commences to be slightly

affected after the temperature has reached approximately 1270 degrees Fahr., but the chemical union forming the carbide is not greatly weakened until a temperature of at least 1400 degrees is reached. In fact, it is, for many reasons, desirable to run the temperature considerably higher than 1400 degrees; and, therefore, below is given a table showing what may be considered safe maximum and minimum annealing temperatures for both pot and muffle type ovens:

	Maximum Degrees Fahr.	Minimum Degrees Fahr.
Pot oven	1650	1450
Muffle oven	1700	1500

Exhaustive tests have shown that prolonged annealing has no detrimental effect upon the physical strength of the product, unless the temperature is run too high, in which case troubles too numerous to mention may result. Prolonged or repeated annealing at high temperatures will, however, have a growing tendency to produce a pearlite rim, which seriously interferes with any machining operation; but, the unreasonable length of time required to produce the rim, under normal annealing conditions, eliminates this as a disturbing factor. Therefore, it would seem only reasonable to assert that when malleable cast iron is seriously over-annealed it is usually because the temperature has been run too high rather than too long. However, on the other hand, it is, I believe, also a safe assertion to state that so far as annealing is concerned more poor-grade malleable cast iron is produced as the result of under-annealing than over-annealing. If the above temperature limits are adhered to and good results do not obtain the trouble is not directly due to annealing temperatures.

Heat distribution sometimes brings up a troublesome problem, the difficulty being to reach the minimum temperature at the coolest point in the oven without exceeding the maximum temperature at the hottest point. This is largely a matter of oven design; and, unless any two points in the oven can be held within the limits herein prescribed, there is something

radically wrong with the oven or the manner in which the burden is arranged. The trouble might be that the flues are not clean.

Time Required to Dissolve Iron Carbide

For reasons not generally understood, it has been found necessary to hold castings at annealing temperature from 60 to 72 hours before the cooling process is commenced. Otherwise, the result will almost invariably show that the iron carbide has not been completely dissolved; that is, the annealed casting will show that a portion of the carbon exists as combined carbon, causing a brittle, inferior product.

It would seem that the chemical union forming the solid solution of carbon in iron is not thoroughly dissolved immediately the annealing temperature has been reached, or, if the iron carbide is completely dissolved in less than 60 hours, we have yet to discover the means of preventing a portion of the carbon from recombining when the casting is cooled to handling temperature. Then, assuming, for the sake of argument, that it has been found necessary to hold the castings at annealing temperature for 60 hours, three questions arise which should invite interesting discussion; namely:

1.—Are 60 hours actually required to dissolve the iron carbide?

2.—Does the iron carbide dissolve in less than 60 hours, the balance of the allotted time being required for precipitation of graphite carbon?

3.—Does the precipitation of graphite carbon immediately follow the gradual dissolution of the iron carbide, requiring 60 hours to complete the conversion process?

I should answer the first question negatively. It is my opinion that dissolution of the iron carbide is very largely a matter of heat penetration, particularly where the muffle type oven is used. In the pot oven, there is little doubt but that the nature and composition of the packing material affects the dissolution of the iron carbide, which assumption is in part at least borne out by the fact that malleable annealing can be successfully conducted with this type of oven at approximately 50 degrees lower temperature than is required in the muffle oven. This does not necessarily mean that the temperature at which the iron carbide is affected in the pot oven is lower than in the

muffle oven. In the pot oven, after say 1400 degrees temperature is reached, it would seem that the effect of the oxide packing material tends to hasten the dissolution of the carbide at a lower ultimate temperature than is required in the muffle oven. In other words, I believe that by skillful manipulation of oven temperatures, the iron carbide can be dissolved in less than 60 hours after annealing temperature has been reached.

In regard to the second question, I am inclined to believe that the iron carbide can be dissolved in less than 60 hours, and that it is the obstinate or lagging precipitation of graphite carbon, at the usual annealing temperature, that delays the conversion process, under present practice. Then, assuming that such is the case, the question arises as to the state of the carbon between dissolution and precipitation. In my opinion, after the annealing temperature has thoroughly penetrated the entire body of the hard iron casting, the chemical union forming the iron carbide is so weakened that the rate of cooling determines whether the carbon will remain in solid solution as combined carbon or precipitate as graphite carbon. In other words, after dissolution of the iron carbide, I believe that the carbon exists in a semi-soluble state, from which it will precipitate as graphite if cooled under proper conditions.

It is doubtless unanimously agreed that the third question covers in a general way about what really happens. In fact, practical tests have shown that where test wedges were removed from the oven at regular intervals before 60 hours had elapsed after the annealing temperature was reached, combined carbon was almost invariably found to exist in direct proportion to the length of time the wedges were held at or above annealing temperature. However, in my mind, this does not prove conclusively that 60 hours are actually required to completely dissolve the iron carbide. On the other hand, I am inclined to think that in the test wedges just referred to the annealing temperature had not completely and uniformly penetrated the entire body of the metal and also in removing the wedges from the oven before the regular period for annealing was completed the cooling was too rapid. In other words, had the annealing temperature been as high as the castings would stand at the commencing of the anneal and the wedges that were withdrawn

before 60 hours of annealing had been completed cooled very slowly, the results would doubtless have shown that a greater percentage of the carbon had precipitated as graphite.

In this connection, I recall an incident where by accident the arch forming a muffle chamber in a muffle type oven fell in and the fire had to be shut off about 36 hours before the regular time. The stack damper and the oven were sealed up practically air-tight and allowed to cool down as slowly as possible, with the result that when the oven was opened the castings were found to be fairly well annealed. The carbide appeared to be completely broken up, but there was scarcely a trace of decarbonization visible without the aid of a microscope. This condition I attribute to the fact that the annealing temperature was high when the accident occurred and the cooling was extremely slow, allowing plenty of time for the precipitation of graphite. It might also be of interest to know that the castings were not scaled. Professor Touceda has done some very enlightening research work along this line, but it has occurred to me that some of the conclusions he has arrived at in regard to the length of time required to break up the iron carbide, may, after further experiments, be altered by the effect of higher initial annealing temperature and slower rate of cooling. It should be thoroughly understood that I take no exception to the conclusions he has reached, based upon the experiments as they were made.

We must realize that one of the greatest drawbacks to the malleable industry is that it takes too long to anneal the castings. While my experience in malleable annealing has not gone far enough to justify any revolutionary results, there is no doubt whatever in my mind, but that the time required under present practice for this operation can be very materially reduced. To that end, if the presentation of this paper stimulates discussion and exchange of opinion regarding the points brought up, its purpose will have been accomplished.

Rate of Cooling

Aside from the absolute necessity of first completely dissolving the iron carbide, the rate of cooling is, in my estimation, of the utmost importance, particularly where it is desired to complete the annealing process in the shortest time possible.

It is generally considered that the sooner the castings can be brought to annealing temperature, the better; but the same rule does not hold true in the matter of cooling to atmospheric temperature after the annealing temperature has been reached and held for the required time. After the iron carbide is dissolved, the object then is to cool the oven under such conditions as will prevent recombining of the carbon. If cooled too fast, all the carbon will not precipitate as graphite.

Practical tests have shown that the recalescence point in cooling malleable cast iron from annealing temperature is slightly under 1400 degrees. Therefore, we will establish 1390 degrees as approximately the critical point in cooling for annealing malleable cast iron, that is, the point in annealing at which graphite will precipitate with most rapidity.

It is held by some authorities that, after the iron carbide is completely dissolved, the castings should be held at or slightly above the critical point in cooling for several hours in order that the precipitation of graphite carbon may be more complete, the theory being that graphite carbon will precipitate with more rapidity the nearer the critical point just referred to is approached. Contrary to such theory, it is the practice of some foundrymen to run the temperature to the highest point just before the fire is shut off; then seal up the oven and, as they express it, "allow the castings to soak". To my mind, such practice is quite the reverse of what it should be. In other words, I am inclined to believe that the nearer the temperature of 1400 is reached in cooling, the more favorable become conditions for the precipitation of graphite carbon, providing, of course, the temperature has previously reached the point where all iron carbide was dissolved. Therefore, it would seem the better practice to reach the highest temperature at the beginning of the anneal, such temperature to be held until the iron carbide is dissolved; then, gradually drop to 1400 degrees, a temperature which some believe will better favor the precipitation of graphite carbon. This would also lessen the danger of warping. In fact, I would not be at all surprised that, when the temperature is run high at the end of the anneal, some of the carbon is, due to being more nearly soluble in iron and lack of

time in cooling, through the transformation range, forced back into solid solution as combined carbon which would otherwise have precipitated as graphite had the temperature not been run so high just before the cooling process was commenced. In some cases, where the sulphur-manganese ratio may not be properly balanced in the hard iron composition, such practice is also much more apt to produce a pearlite rim or "picture-frame" fracture, a source of extreme annoyance where the castings have to be machined. However, this condition is rarely, if ever, produced by annealing alone, except where the annealing is prolonged almost indefinitely or the temperature run entirely too high.

A point which might have been mentioned in connection with establishing the critical point in cooling is that, while approximately 1390 degrees represents the point in temperature at which graphite carbon precipitates with most rapidity (assuming, of course, that the iron carbide has been dissolved by subsequent heating at higher temperature), it does not necessarily follow that the precipitation of graphite ceases immediately the temperature drops below 1390 degrees. In fact, the precipitation of graphite carbon, in some cases, may continue until the temperature drops to 1274 degrees, below which temperature all precipitation is arrested. Therefore, in reality, 1274 degrees is the critical point for dissolution of the iron carbide; or, in other words, this is the temperature at which the chemical union forming the carbide commences to weaken upon heating and is also the point at which the precipitation of graphite carbon ceases upon cooling. Malleable iron annealing could not be successfully conducted at either 1390 or 1274 degrees temperature, if at all, due to the length of time that would be required to dissolve the iron carbide; and, therefore, these temperatures are extremely important only in the matter of cooling the castings from annealing to handling temperature.

As to the effect of further cooling between the temperature of 1274 degrees and handling temperature of the castings, this, I believe, depends solely upon the condition of the carbon when the temperature of 1274 degrees in cooling was passed. Where combined carbon is present, the effect of the rate of cooling upon that part of the structure representing the carbide would

be about parallel to the tempering of a piece of soft steel of the same carbon content, heated and cooled under similar conditions. In other words, the more rapid the cooling, the harder would become the crystallization of the carbide and consequently the more brittle the casting; and, vice-versa. Were all the carbon in graphitic form at 1274 degrees temperature, the cooling might be forced to handling temperature without detriment to the physical characteristics of the metal. This is based upon the theory that iron and free carbon are not readily, if at all, soluble at 1274 degrees Fahr.; therefore, the formation of iron carbide is impossible, and where there is not combined carbon present in ferrous metal it can usually be hardened very little by tempering. As a practical test, a well-annealed malleable test wedge was heated in a hand-forge to a cherry red and quenched in cold water, without the slightest effect upon the ductility of the metal or condition of the carbon. Then, a duplicate wedge was heated to a slightly higher temperature and cooled under the same conditions, with the result that the carbon was re-combined and the metal very brittle, showing a steely, white fracture. In the first test the critical point was not reached where the iron and free graphite were soluble; and, as practically no carbide was present to commence with, the metal was not hardened to any noticeable extent by tempering. In the second test it would seem that the temperature was reached where the free graphite became dissolved in iron and by sudden cooling through the critical range was forced into solid solution as combined carbon, which composition was still further hardened by tempering.

The point which I wish to make clear is that where conditions have been ideal for conversion of the carbon, more liberty can be taken in cooling the castings from 1274 degrees Fahr. to handling temperature, thus saving considerable time at present allowed for gradual cooling through the same range of temperature.

Removal of Carbon

It is possible to accomplish the conversion or annealing process without removing any carbon whatever; but, as this is neither practical nor desirable, it will not be discussed. The removal of carbon is entirely the result of oxidation; and,

where no oxygen is present, no carbon can be removed. Oxygen for the removal of carbon in malleable iron annealing is supplied usually by an oxide packing material or by air, depending upon the type of annealing oven used.

For years it was thought that malleable iron annealing could not be accomplished unless the hard iron castings were packed in iron-oxide scale; but, as the tonnage of the industry rapidly increased, this packing material became harder to obtain, with the result that today most any kind of refractory material is used in the place of iron-oxide scale, and with comparatively good results. Some plants have even gone so far as to adopt the muffle-type oven, where no packing material at all is used. The castings are simply stacked up in the oven and protected from contact with the flame by muffled chambers or by covering with sheet-iron plates and sand or scale. Practically the only difference in the results obtained is that more carbon is removed from the casting where a strong oxide packing material is used, as will be shown later on in this paper.

While decarbonization or the removal of carbon in the anneal is in most cases desirable, some, I am afraid, are disposed to over-estimate its importance. In other words, it is the complete conversion rather than the removal of carbon in the anneal that determines the malleability of the product. It is a well-known fact that the higher the total carbon content in malleable cast iron (even though the conversion in the anneal be perfect), the lower will be its ultimate strength, the strength being affected in direct proportion to the minute cavities made necessary for graphite deposits in the ferrite structure. Even so, it does not necessarily follow, by any means, that the removal of carbon in the anneal is absolutely essential to the production of high-grade malleable iron. While at least a small amount of carbon will always be removed in the anneal, the total carbon should be regulated in the white iron—a fact which cannot be too forcibly impressed upon those who desire to maintain a high-grade product.

While possibly somewhat foreign to my subject, the statement just made again emphasizes the importance of knowing the carbon content of the pig iron entering into the mixture when charged into the melting furnace, inasmuch as the color

method for making preliminary carbon tests, as used in steel practice, cannot be employed by the malleable melter, because the total carbon in hard iron is so much higher than in steel. Unless the total carbon can be regulated with some degree of accuracy more than guess-work in the melting mixture, the hard iron will not be of such consistency that we can reasonably expect uniform results to obtain in the anneal, regardless of the type of oven or annealing practice employed. Therefore, I again call to the attention of the association a most valuable service which can be performed for its malleable members by setting into motion some plan for a united request or demand upon pig iron dealers to furnish and guarantee the total carbon analyses, as well as the various elements which it is their present practice to supply.

To further emphasize the importance of regulating the total carbon in the hard iron, I can state as an absolute fact that the best malleable cast iron never results from a hard iron composition in which the total carbon is around 3.00 per cent, regardless of the amount of carbon removed in the anneal. However, in this connection, caution should be used not to run the carbon too low, else trouble will result from other sources. If the total carbon is allowed to go below 2.20 per cent in the hard iron, the iron carbide will not dissolve under ordinary annealing temperatures, which is only one of the numerous troubles that will result from running the carbon too low.

In another part of this paper the statement is made that prolonged annealing will have no detrimental effect upon the physical strength of malleable cast iron, unless the temperature is run too high; also, that the removal of carbon in the anneal is not essential to the production of high-grade malleable iron. These statements are best corroborated by a series of practical tests conducted by Prof. Touceda, to whose liberal generosity I am indebted for many favors. In one of these tests eight test wedges were poured from the same ladle of iron and annealed in such manner that one of the wedges was annealed eight times, one seven times, and so on down the line until one of the wedges received only one anneal. Physical tests showed that there was practically no difference in ductility

between the wedge annealed once and the one annealed eight times; and, after each successive anneal, the physical test showed but very little comparative variation in strength. Upon analytical examination, however, it was found that the total carbon was diminished by each successive anneal—the first anneal showing a total carbon of 1.40 per cent, while the eighth anneal showed that only 0.22 per cent of carbon remained. The test showed conclusively that the consistent removal of carbon in each successive anneal did not improve the quality of the product; and, at the same time, it demonstrated that prolonged or re-annealing, under normal conditions, will not affect the strength of the metal.

Muffle Oven Versus Pot Oven

There are two types of oven generally used for annealing malleable cast iron; namely, the muffle oven and the pot oven, either of which has its particular advantages and disadvantages. The typical muffle oven is in reality an oven built within an oven, that is, the construction of the outside oven, or oven proper, is very similar to the pot oven, except that it encloses two small arches, separated by a partition, which form the muffle chambers in which the castings are placed for annealing. When filled with castings, the muffle chambers are sealed up as nearly air-tight as possible. The fire-box is arranged usually at the rear end of the oven in such manner that the flame passes directly over the arches of the muffle, returning through specially constructed flues in either side-wall and underneath the floor to the main stack flue at the back end of the oven directly underneath the fire-box. There is, of course, a damper in the base of the stack for regulating the distribution of heat throughout the oven, which is a simple matter if the flues are kept clean.

In regard to the pot oven, I take it that all present are familiar with the general design of this type of oven and that a brief description is unnecessary. It is nothing more or less than the muffle oven, minus the muffle chambers.

The principal advantages in favor of the muffle type oven are the elimination of labor required to pack, handle and shake out the pots, cost of packing material, expense of renewing

pots, etc. Among the objections to the muffle oven may be noted the following:

1. On account of the heat having to penetrate the brick arch forming the muffle chamber, it requires somewhat longer to bring the castings to annealing temperature.
2. Not being supported by packing material, the castings are more apt to become warped or contorted.
3. There is more danger of the castings becoming scaled, due to air leaking into the muffle.
4. Small and delicately constructed castings cannot be annealed in this type of oven unless they are packed in trays.

The muffle-type oven is particularly adapted to annealing medium and heavy castings, where packing material is not necessary to prevent warping and where a small amount of scale on the castings is not a serious objection. For this class of work the muffle type oven has everything in its favor.

The pot oven is used by some foundrymen probably because they have never tried any other method of annealing; by others, because the nature of their work requires that the castings be annealed in packing, There is no doubt but that the pot anneal produces a cleaner and better casting for machining or nickel-plating, but so far as physical strength is concerned, the pot oven has no particular advantage over the muffle oven. Of course, the principal objection to the pot oven is the expense and inconvenience of packing the castings in pots. However, where light and intricate castings are to be annealed, I can suggest no alternative.

For the purpose of further proving certain statements made in this paper, I have had cast from the same ladle of iron a set of 30 test wedges and 30 tensile test bars. These were annealed in three lots of 10 wedges and 10 tensile bars each. Two lots of these tests were annealed in a pot oven, one lot being packed in mild packing material and one lot in strong packing material. The mild packing material was mill scale mixed with coke breeze; the strong packing material was iron-oxide scale. The third lot of tests was annealed in a muffle type oven, without packing material. The comparative results are shown in the accompanying table.

Total carbon in hard iron was determined from hard iron shot, cast in water. The carbon determinations after anneal were made from drillings taken entirely through the butt end

of test wedges. The test wedge was 6 inches long, 1 inch wide, ½ inch thick at butt, and tapered to wedge point. The tensile test bars were round, ⅝ inch in diameter. Each of the above tests represents the average for 10 bars, five of them being annealed near the roof and five near the floor of the oven, about midway between front and back end.

Unfortunately, the heat from which the above tests were poured was too high in both carbon and manganese to produce an extremely ductile and tough material. However, it accomplished the purpose for which the tests were made.

By reference to the tabulated results, it will be noted that the mild packing material removed less carbon than the strong packing and that more combined carbon remained in the iron annealed in mild packing, which strengthens the statement previously made that in addition to removing more carbon the oxide packing material has a tendency to hasten the dissolution of the carbide after annealing temperature has been reached. I would also call attention to the fact that, while the muffle-type oven removed less carbon than the oxide packing material in the pot oven did, the conversion of carbon in the muffle oven was more nearly complete. This, in conjunction with the results of the physical tests, proves that it is the conversion rather than the removal of carbon in the anneal that produces ductility.

In closing, I wish to express my appreciation of services rendered to the writer by the Eastern Malleable Iron Co., in whose laboratory some of the tests herein referred to were made.

COMPARATIVE RESULTS OF POT OVEN AND MUFFLE OVEN ANNEALING

	POT OVEN Mild Packing.	POT OVEN Strong Packing.	MUFFLE OVEN Without Packing.
Total carbon in hard iron (per cent)	2.63	2.63	2.63
Combined carbon after anneal (per cent)	0.53	0.13	0.05
Graphitic carbon after anneal (per cent)	1.75	1.85	2.12
Total carbon after anneal (per cent)	2.28	1.98	2.17
Total carbon removed in anneal (per cent)	0.35	0.65	0.46
Wedge test (length of butt in inches)	2⅞	2⅜	2
Tensile strength (pounds per square inch)	49,448	50,044	49,542
Elastic limit (pounds per square inch)	38,746	37,122	37,398
Elongation (per cent in 2 inches)	6.3	6.7	7.3

Discussion

A Member:—I find that the bigger man, the boss, is always after the superintendent or factory manager to reduce the time of annealing as much as possible, because he always wants the castings to get out of the furnace or shop as soon as possible. In my experience I find that the reason we cannot cut the time of annealing is because we have a variation in the temperature of our annealing furnaces, in some cases as much as 100, 150 and 200 degrees from one place in the furnace to another. If we could control this temperature we would attempt to anneal our castings at the critical range.

Mr. J. B. Deisher:—I think the point that has been brought up here, more than anything else, is the question of oven design. Where it is important to get castings in the shortest length of time possible, smaller ovens should be used rather than large ones. With an oven of the proper design intelligently handled, I think the temperatures could be so controlled that no trouble would be encountered.

Mr. C. H. Gale:—I would like to ask Mr. Deisher if in his study of the comparative losses in carbon between muffle and pot annealing, he has made any study as to the percentage of carbon actually lost in the annealing process.

Mr. J. B. Deisher:—Yes. You will find that in the comparative table given in the last page of the printed paper.

Mr. C. H. Gale:—I find here in one case total carbon in hard iron was 2.63 per cent and the total carbon, after annealing, was 2.28 per cent, which would give a loss of nearly 0.4 per cent.

Mr. J. B. Deisher:—That shows that more carbon is removed by strong packing because it creates a stronger oxidizing influence in the oven.

Mr. C. H. Gale:—I have always made it a point, in so far as the time of annealing is concerned, to err on the over side rather than on the under side, believing that a little over-annealing doesn't hurt, whereas under-annealing does a lot of

harm. Of course, we know that the further the anneal is carried, the greater the carbon loss will be.

Mr. J. B. Deisher:—The castings might be scaled by excessive oxidation, in which case the weight of the iron taken from the castings to form the scale (iron oxide) would show a further loss. This frequently occurs with the muffle type oven when air leaks into the muffle.

Mr. C. H. Gale:—That would be governed largely by the extent to which the annealing was carried, and the temperature. The higher the temperature the greater the loss. But I place 1 per cent carbon loss as the maximum, and run from that down to 0.5 per cent. In one case the piece of iron weighed 333.11 grams. I was very careful about weighing before annealing. After annealing and cleaning with a brush so as not to wear off any of the iron, it weighed 329.452 grams, a loss of about 1.1 per cent.

Mr. J. B. Deisher:—There was absolutely no scale on the casting as the result of excess oxidation, was there?

Mr. C. H. Gale:—No, there wasn't.

Mr. A. M. Fulton:—Would the author in his opinion attempt to keep his temperature at the maximum or minimum or get in between?

Mr. J. B. Deisher:—At the beginning of the anneal, the higher the temperature is run the more applicable and effective it is upon the dissolution of the iron carbide. I do not think the oven should be run to the maximum limit just before it is cooled off and then cooled rapidly from the maximum limit through the transformation range. However, upon bringing the oven up to annealing heat the sooner you reach 1700 the better.

Mr. A. M. Fulton:—You confine your anneals to the 1700 range all the time?

Mr. J. B. Deisher:—No; for the first 30 or 40 hours. Then I would keep it around 1600.

Mr. A. M. Fulton:—Then your idea is to bring your temperature up to 1700 degrees and then drop to 1600?

Mr. J. B. Deisher:—Yes; keep it at 1700 for 30 hours, then drop to 1600 and hold it until the iron carbide is so weakened that the carbon will precipitate as free graphite.

The Effect of Iron Oxide in Molding Sand

By W. R. Bean, Naugatuck, Conn.

The effect of the presence of iron oxide even in small amounts in molding sand is detrimental and militates against the best results in the production of small and medium weight castings, especially where clean metal and good surface finish are of prime importance. Nearly all molding sands, as taken from the earth, contain iron oxide. Obviously that sand possessing the smallest amount is the best, other elements being equal. This statement may seem a broad one, but it is based on three separate experiences in which careful analysis and study of the conditions proved iron oxide to be the source of the trouble experienced.

In the production of castings requiring a large number of cores, the greater part of which could not be separated from the molding sand in taking out the castings, the expense of maintaining the sand in proper condition by the addition of new sand was found to be unusually high. In looking about for material to be added as a binder it was found that the fine dust deposited at the dust arrester in a hard iron cleaning system possessed unusual bonding qualities when mixed alone. Therefore, permission was given to add this to the sand pile on a machine floor.

It was very soon demonstrated that the addition of this material was not accomplishing the desired results. On the other hand, conditions were made much worse, as evidenced in sand washing where the metal flowed over the mold surface and in "drops" where any amount of sand was left suspended. The trouble was not at this time attributed directly to the presence of

iron oxide but later experiences proved this to have been the cause.

Sand Burned into Pockets of Castings

While endeavoring to lower the cost of sand maintenance, a molding sand was found, which in the fresh or new state seemed to possess unusual bonding qualities. Several carloads of this sand were ordered and put into use on two machine floors requiring a large amount of sand. The quantity added at the start was the same as that previously used of a sand which met the requirements but entailed a heavy expense. The new sand gave approximately the same results as that from the dust collectors, except that it burned so hard in the pockets of castings that it was practically impossible to remove it by the ordinary methods of cleaning.

To determine what chemical elements might be present in this sand which would account for this result, complete chemical analysis was made. Unfortunately I have not the exact figures and although it is now several years since the occurrence, I clearly recollect that the amount of iron oxide in the new sand was slightly in excess of 5 per cent. The use of that sand was immediately discontinued and the original sand was again employed. In a short time the trouble disappeared.

In 1913, while making an investigation of a continuous mechanical foundry plant having all of the latest devices for preparing and handling molding sand, I found that a great deal of trouble was being experienced as a result of the sand forming in small, hard lumps which would not disintegrate in any of the screening or sand rolling units of the equipment. Investigation of the source of the sand supply and of the disposal of sand from the dust collector showed that the new sand was of fair quality, but that the sand from the dust collector was being returned to the molding sand conveying and preparing units.

Molding Sand Formed in Lumps

Analyses made by Booth, Garrett & Blair showed that the new molding sand in stock contained 3.5 per cent iron oxide. The lumps of sand formed in the sand handling units contained 8.5 per cent iron oxide, and material from the dust collectors contained

6.61 per cent iron oxide, with 4 per cent magnetic iron in very small particles. My conclusions were that the source of trouble was in the addition of this fine dust from the dust collectors. That these conclusions were correct was proved by the fact that in a short time after the addition of this material was discontinued and new sand added, the lumping of the sand disappeared.

The action which takes place is a combination of this oxide material with the silica contained in the sand to form a silicate of iron, temperatures produced by contact of hot metal with the mold surface being sufficiently high to cause the combination.

From my experience in the use of molding sand in the malleable industry, I feel that so far as the surface finish of castings is involved, the elements in the sand which have a bearing on the results may be divided into two classes—those which burn out and cause roughness of the casting surface as a result of penetration of the metal into the mold surface, and those which combine with the iron to leave a depression in the casting surface when these are subjected to a severe cleaning such as sandblasting. Iron oxide I believe to be the principle element in this class.

Sea Coal Facing Not Beneficial

A series of tests recently made with various facing mixtures prepared by passing the material through riddles or sand mullers or mixers affords further proof of the accuracy of the statement made regarding the effect of the presence of iron oxide in molding sand, the best surface finish being obtained by the use of a facing of new fine molding sand put through a sand mixer or muller without the addition of sea coal facing or any other element.

Castings from molds faced with a mixture containing one part medium sea coal facing, six parts new fine molding sand and 14 parts of fine dust from the dust collector, show both depressions and projections on the surface after sand-blasting. The mixture is tempered with a wash of one part glucor and four parts water, which is used to bind the facing. It appears that the projections on the surface of the castings result from

burning out the fusible elements or materials and that the depressions result from the formation of more iron oxide than is present in the sand at the time of casting, according to the equation,

$$2\,Fe_2O_3 + 2Fe = 6\ FeO,$$

or from other chemical combinations.

The irregularities in the surface of the castings are present whether the sand is mixed by hand and passed through a fine riddle or mixed by passing through a sand muller or mixer, but the latter treatment of the facing gives a much better appearing casting surface.

A further test was made by taking the same material as used in the mixture referred to above except that the iron and iron oxide had been removed from the fine dust from the dust collector by dissolving these out with hydrochloric acid, leaving the sand practically free from any iron content. This mixture, prepared in a sand muller, produced castings with a finish practically equal to that obtained by using fine molding sand as a facing.

Nature Blends Elements in Sand

I have seen clay added in the form of a wash for tempering and for restoring the bond in molding sand in mechanical handling systems and while this method may have merit for heavy work it failed to produce the desired result for light castings. Nature seems to blend the silica and alumina, the principal elements in molding sand, better than we can do it by mechanical means. Alumina is the element that needs replacing, partly because it goes off in dust from handling the sand, but more, in many cases at least, to counteract the silica added in the form of core sand of which the chief element is silica. There may be equipment suitable for economically and satisfactorily blending the elements forming molding sand mechanically, and recent investigation indicates that this is true. However, even with a suitable means of reclaiming sand to the extent of restoring its bond by mechanically coating the silica grains with alumina, provision still must be made to take care of the iron oxide content. Possibly a magnetic separator of high power may prove adequate for this purpose.

Discussion

THE CHAIRMAN, MR. S. GRISWOLD FLAGG, III:—Are we to take it from your paper that you consider better surface castings can be turned out by treating new sand than by using any facing material?

MR. W. R. BEAN:—That is my experience in the production of light castings. I am not referring now to heavy work or anything of that character.

THE CHAIRMAN, MR. S. GRISWOLD FLAGG, III:—One thing I think, probably, you found out too, Mr. Bean, that the dryer your sand is, the better.

MR. W. R. BEAN:—Obviously. Work it as dry as you can.

MR. PAGE:—We make a lot of gray iron castings. Our experience has been we get a finer and higher grade finish without the use of any facing at all. The castings run light, most of them very light, and we make some castings up as high as 100 pounds practically without facing of any kind and get a finer finish than we get with any of the facings.

MR. W. R. BEAN:—Reference is made in the paper to an experience with a mechanically operated or continuous foundry plant and in that case clay wash was added in the tempering units. I believe that it is possible to do something in this line with the pan mixer, and I believe further that by taking gangway sand it is possible to get cut the very fine sand and that almost all of the sand that is now thrown out in the average foundry operations can be used to greater or less advantage depending on the delivered price of new sand.

MR. A. L. POLLARD:—Wouldn't that old sand carry a considerable percentage of iron oxide?

MR. W. R. BEAN:—Yes; unless it is passed over a heavy magnetic separator. Some iron oxide is magnetic; some is not. We are able to take out with an ordinary magnet around 3 or 4 per cent of very fine iron.

Mr. J. Shaw:—I was much interested in Mr. Bean's remarks on molding sands and iron oxide. I think his deductions are drawn from wrong conclusions. Your best sands contain anything from 4 per cent upwards (Albany, 3.92 per cent), and both Morse and Knight say "A moderate amount of iron oxide seems to be desirable, enabling a sand to last longer and to better resist the washing tendencies of the stream of metal, probably by partly fusing with the silica, when the metal comes in contact with it and thus forming a more coherent surface". (Silicate of iron melts at 1800 degrees.)

The addition of fine dust to any sand is bad and it is only what you would expect that the conditions would be unsatisfactory. With regard to the sand-burned pockets, the iron oxide is nearly all in the clay and most probably the large percentage of iron oxide found in the pockets simply denoted large excess of clay which would also account for the hardness in the pockets.

Mr. Bean's loose way of using the word alumina in my judgment indicates carelessness or lack of knowledge. Your Mr. Field has several times pointed out that alumina is not clay, but only one of its constituents. Alumina is not the element that needs replacing by crushing old bricks fine (you could add the same elements except the combined water) nor are silica grains coated with alumina, except as a constituent of clay. While chemical analysis is certainly helpful it is the combinations you want to know. I append an analysis of a sand that is being successfully used in the north of England: Bolden sand, silicon, 88.36 per cent; aluminum, 4.35 per cent; oxygen, 0.71 per cent; lime, 1.60 per cent; magnesium, 0.74 per cent; alkali (as soda), 1.70 per cent, and loss on ignition, 2.59 per cent. We are obliged to use local sands because of the war. Please note the lime. This is constituent of a dolomite, hence its heat resistance.

Molding and Casting Large Slag Pots

By C. J. McMahon, Chicago

Slag pots, or cinder ladles, as they are sometimes called, are important adjuncts to the production of iron and steel, forming, as they do, a convenient means of accumulating and transporting liquid slag, a residue formed in all iron and steel-making processes, which, in blast furnace practice, exceeds in bulk the output of iron.

The making of these castings presents no problems which the practical foundryman has not solved, but of the existing methods of production there is certainly a question as to which yields the most in speed and economy, combined with quality.

Of the several methods in force today, two stand out in my mind as being most desirable. As far as the rest are concerned, some are prodigal of both time and labor, and at least one verges on the archaic. In the interests of brevity, and from a desire to make purely a positive argument, I will discuss but two methods.

The jobbing foundry receiving infrequently an order for one casting of this class should, in my judgment, pin its faith to the single-sweep method. When following this method, the drag is swept-up in a hole or pit in the floor to the size of the cope; the cope is then rammed with a suitable arbor and lifted; and the drag is then shoveled out to the necessary depth to clear the sweep with a strip attached, the strip being of the same thickness as the metal in the casting. After applying facing, the drag is again swept and finished. This method presupposes the use of dry sand for large castings.

When Special Rigging Helps

Another method, involving the use of special rigging, will be found a profitable investment for the foundry turning out a large number of castings of this class. No claims are made

as to its originality or novelty, but it will be found to be thoroughly practical and economical of time and labor.

The practice to be outlined is in use in a foundry making from 50 to 100 slag pots every year. Both iron and steel pots of any size may be made. The molding may be done with sweeps, the castings being made in dry sand or loam, but in the following resume the practice is dry sand.

The cope is swept-up on a cone-shaped barrel designed for a standard-sized pot. This cone consists of eight flanged, seg-

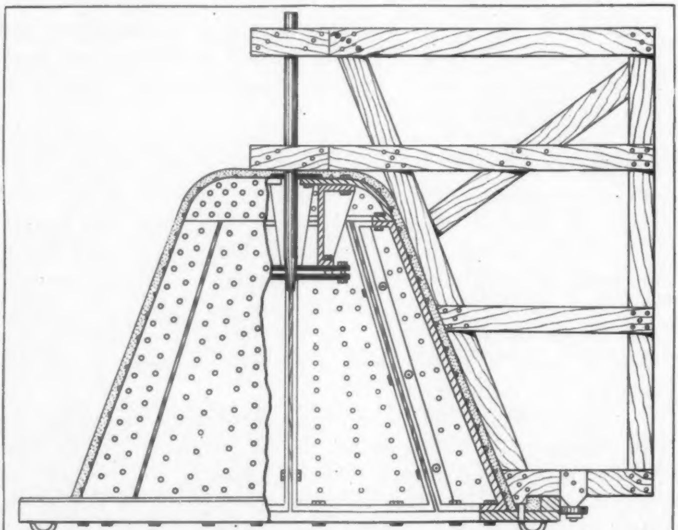


FIG. 1—CONE-SHAPED BARREL ON WHICH THE COPE IS SWEPT-UP

ment-plates cast with prickers and cored vent holes. These segment-plates are bolted together and are also bolted on top in the molding position to a cast iron piece which is called the nose. They also are bolted on the bottom to a steel ring which forms the joint or bearing of the cope. This joint-ring, which has openings for the pressure relieving risers, should be machined on the joint side, and on the outside to form a true circle for the guiding wheel on the sweep.

A strip of dry pine 1 inch wide and the length of the segment is inserted in each plate joint. These strips burn out after casting, thus allowing for contraction. In lieu of pine strips, tapered wedges of iron or steel may be used. As a matter of fact, in making steel pots, metal wedges must be used. The steel, owing to its rapid solidification, and consequent contraction would not permit the wood to burn completely.

Facing Mixture

All bolts are then tightened, clay wash is applied, the sweep set, and the cope is ready for ramming. The facing consists of one-third new sand and two-thirds old sand, with dry core compound as the binder. The cope is rammed and swept in the usual manner, finished, blacked and dried on the floor with a wood fire under the barrel. Drying takes place over night.

In preparing the cone-shaped barrel for the steel pot, steel wedges, 4 inches wide, 2 inches thick, tapering to 1 inch, and of the length of segment are inserted as described previously, after which the barrel is securely tightened. The facing for steel pots is 14 parts silica sand to one of fire clay, wet with Glutrin water. The cope is rammed and finished as in standard practice, and dried on the floor with a wood fire.

The drag for iron pots is made in a brick-lined pit, which with the sweep in position allows for the sweeping of approximately 2 inches of sand. Recesses are provided for the lugs or rests cast on the outside of the pot, which are made in cores, and set by sweep marks. A space also is provided for laying the tile for bottom pouring; two rows of tile laid 1 foot above the bottom of the drag form the gates from the single vertical tile or sprue.

A circular steel ring, machined and fitted with movable guides, forms the top and the bearing or joint of drag. This top plate is securely anchored by bolts to another plate in the bottom of the pit.

The movable guides are set by a projection on the sweep, which is the radius of the steel ring used on the cope. The spindle, set in a seat in the bottom of the pit, is centered and held rigid at the top by two steel angles made for the job and

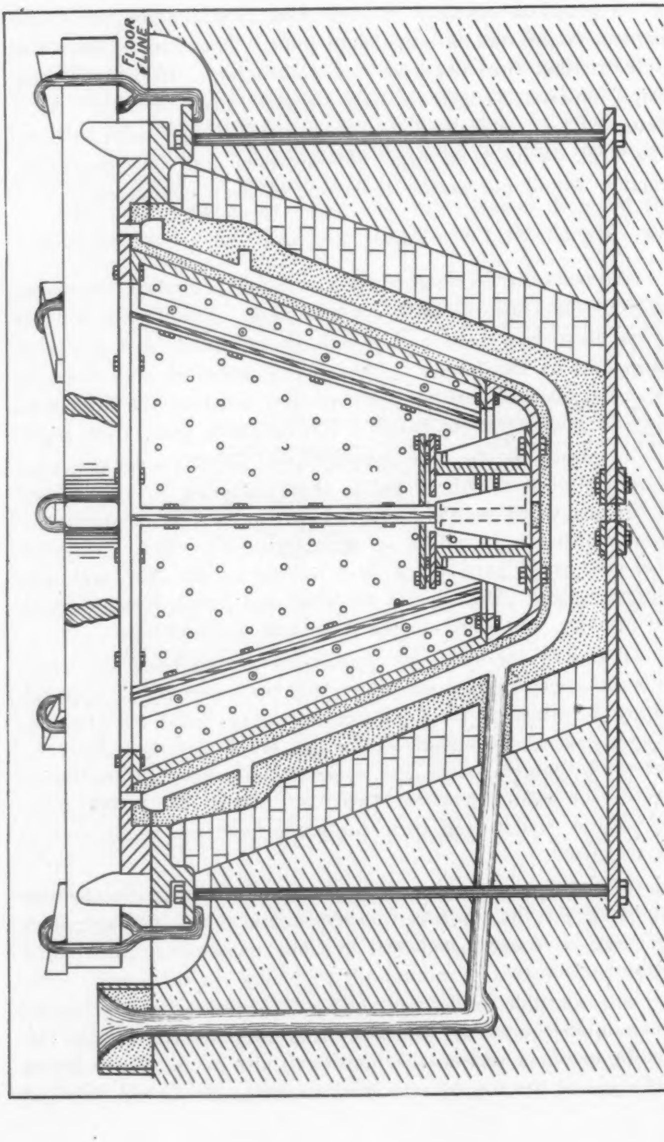


FIG. 2—CROSS SECTION OF SLAG-POT MOLD

bolted to two columns. After ramming and finishing, a coke salamander is suspended in the drag, and a cover applied. Drying takes place over night.

Drag for Steel Pots

For steel pots, the drag is made essentially the same as for iron, with the exception of the kind of sand used and the gates, which are two in number, placed one above the other about 4 feet apart.

In closing, the cope is rolled-over on a pile of soft sand about 4 feet deep, covered with bags which protect the cope from moisture. The success of this method of rolling-over is attested by the small number of shake-outs. The pots are held down by a six-arm cast-steel cross, which measures about 15 feet in diameter. The cross section of the arms is 12 x 2 inches. A forged steel loop is slipped over each arm. On the opposite end of the loop is a toe, which is hooked under the top plate of the pit. Steel wedges are then driven between the loops and the arms of the cross, and the job is secured against the enormous pressure encountered in castings of this kind. Weights may be laid on the cross as an additional precaution if thought necessary.

Bottom-pour ladles are employed for casting both steel and iron pots, which take from 18,000 to 20,000 pounds of metal. Bessemer iron direct from the blast furnace is used. Occasionally it is mixed with cupola iron. The steel is of the same specifications as the regular run of steel castings. After casting, and when a sufficient length of time has elapsed to allow for cooling, and for the burning of the wood strips if they are used, the barrel is loosened by lifting each lug alternately. It is then lifted out entirely. The barrel may be immediately rolled-over and set up ready for another ramming.

In the foundry from which the practice quoted here is taken, 50 steel pots and 60 iron pots were cast successfully during the year 1916. Three pots of either steel or iron can be cast per week with a single barrel and pit.

Use of Vanadium in the Manufacture of Steel Castings

By J. Lloyd Uhler, Pittsburgh

Vanadium is not a new discovery. Its existence was known as far back as a century ago, under the name of erythroniun. It was not until 30 years later that it was again found and given its present name. About 50 years ago Sir Henry Roscoe is credited with having obtained the pure metal and learning something of its properties, particularly its ability to combine with oxygen.

For a great many years vanadium was classed among the rare elements. It was used in steel only in an experimental way up to the first part of 1907, although before that it had been used for several years in small quantities by English wire drawers. It was found to occur in small percentages in combination with other metals, and the cost of reduction made the price prohibitive. Even after, in 1905, a large deposit was discovered in Peru, South America, which caused the price to be lowered considerably, its cost was still so high as to prohibit its use in steel manufacture generally, and it was not until American interests acquired this property and started to bring the ore out in comparatively large quantities that the price was brought to a level that permitted of a broad use of the alloy in the manufacture of vanadium steel.

For many years it has been an axiom that phosphorus and sulphur are the two deadly enemies of steel. But with the aid of the wonderful science of chemistry, which is only a little over 100 years old—its application to steelmaking dates back only about half that period—the most advanced metallurgists have just begun to appreciate that there are other elements which are much more harmful. The two exceedingly elusive gases, oxygen and nitrogen, are usually present in small quantities in all forms of steel and the presence of either one is exceedingly harmful.

Vanadium, even in small doses, has the property of combining with both oxygen and nitrogen at high temperatures. In fact, it acts as a purge or cleanser in eliminating these gases from the metal. It is claimed by noted investigators that its influence is so powerful that 0.5 per cent is sufficient to eliminate nitrogen entirely. Its effect on oxygen is the same,

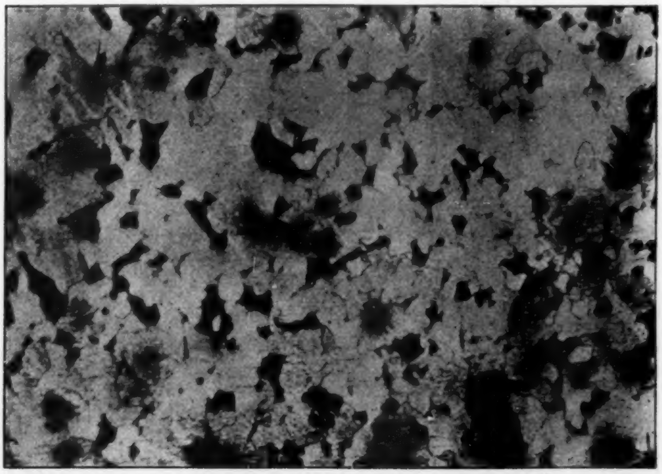


FIG. 1—MICROGRAPH OF VANADIUM STEEL ANNEALED AT 1575 DEGREES
Carbon, 0.28 per cent; Manganese, 0.58 per cent; Silicon, 0.26 per cent; Vanadium, 0.16 per cent. Magnification, 150 diameters.

but this is not nearly so important, as we have other much less expensive materials which will take care of this element under ordinary circumstances.

Vanadium, in addition to its chemical action on nitrogen and oxygen, also produces another result which has been called a mechanical action, although it is more properly another chemical combination. The microscope reveals beyond question that the presence of this alloy produces a rearrangement of hardening carbon, causing it to be more uniformly knit together throughout the mass.

Vanadium steel which has been properly treated has higher tensile strength, higher elastic limit and resistance to fracture

from successive shocks than would be shown by carbon steel of similar chemical composition. It must not be supposed for an instant that vanadium is a miraculous substance or "cure all" which will neutralize the effects of phosphorus and sulphur, or that it will make bad steel good. The steelmaker or consumer who is led astray on any such idea still has his troubles

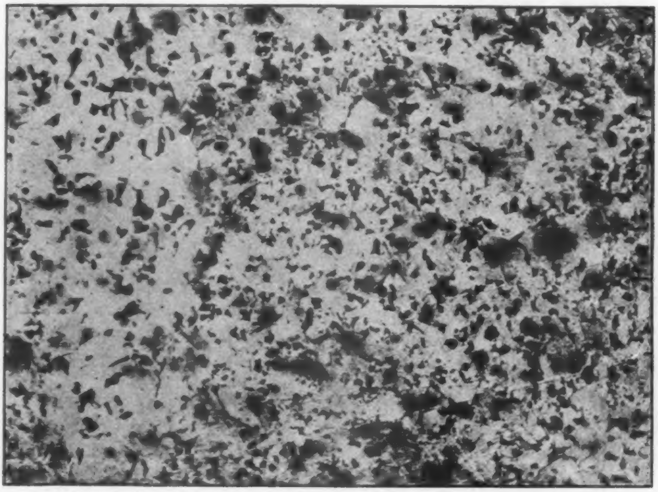


FIG. 2—THE SAME TEST COUPON AS SHOWN IN FIG. 1 MAGNIFIED 60 DIAMETERS

Elastic Limit, 48,210 pounds; Tensile Strength, 79,930 pounds; Elongation, 26.6 per cent; Reduction of Area, 48.1 per cent.

ahead. It is a fundamental fact that results obtained with any combination having iron as its base will be in direct proportion to the amount of phosphorus and sulphur present.

Any steelmaker who has worked with vanadium alloys or any other alloy should know how essential it is that the correct analysis of the alloy being used, as to silicon, vanadium, nickel, sulphur, manganese, aluminum and carbon content, be determined, especially the nickel, sulphur and silicon, as with this knowledge many of the troubles encountered in the manufacture of alloy steels can be warded against.

Vanadium is an almost unique, and certainly by far the most prominent example in the history of metallurgy of an element which has suddenly bounded from the position of a museum curiosity to extended practical application in industry.

In 1907 the American Vanadium Co., through the untiring efforts of its metallurgist, J. Kent Smith, prevailed upon the company with which the writer is connected, to make a trial

FIG. 3—THE SAME TEST PIECE MAGNIFIED 30 DIAMETERS

heat of vanadium steel for locomotive frames. They were used for experimental road tests. These were the first vanadium castings made in the United States, and from 1907, the pioneer year, the demand for vanadium-steel locomotive frames and other parts has gradually increased. Now this work is a part of our regular daily output; the major part of each cast goes into castings of this class and also into a variety of smaller or larger castings, such as pinions, gears, rotors, bridge rollers, locomotive cylinders, driving wheel centers and a good many other castings which require a steel with dynamic as well as static qualities greater than plain carbon steels are able to show with the same chemical composition.

Vanadium steel not only imparts a very high elastic limit without reducing the ductility and toughness, but also confers on steel greater resistance to deterioration under stress. This has been demonstrated both by extensive laboratory tests and also by long practical service trials.

As modern engineering requirements have become more and more drastic in respect to the power to resist rapidly re-

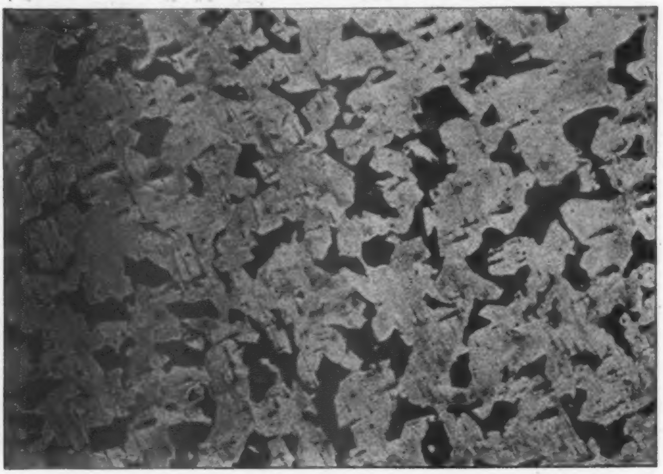


FIG. 4—ANOTHER MICROGRAPH OF THE SAME TEST PIECE MAGNIFIED 60 DIAMETERS

peated strains and shocks, with increased requirements as to actual strength, it has become necessary to resort to vanadium steel, which has been chosen to fulfill these demands.

In the manufacture of vanadium steel, great care should be taken not to melt with too thin a slag, as this allows the metal to become oxidized. The alloy should not be required to cleanse the bath of all impurities brought about by bad furnace practice.

When flowing into the mold there is a greasy or oily skum which floats on the surface of all properly made vanadium steel. It is much more noticeable than on plain carbon steels. Vana-

dium steel, like other alloy steels, should be treated carefully as the grain structure can be impaired to such an extent as to make the product worthless. The heat treatment should be carried out in the manner dictated by experience gained from repeated experiments. I will give below some static and dynamic results obtained from simple carbon vanadium steels. The results are as follows:

	A	*B*	*C*
Elastic limit, pounds per square inch	48,210	47,250	49,550
Tensile strength, pounds per square inch	79,930	86,050	85,400
Elongation in 2 inches, per cent	26.6	27.5	28.5
Reduction of area, per cent	48.1	49.3	50.4
Bend Test—120 degrees over 1-inch mandrel		over 120	OK
Vibration or dynamic test		2851	3124

The tests given below were made from coupons taken from castings which were made to take the place of forgings for marine turbines. They were made to the following forging specifications: Tensile strength, 67,159 to 78,227 pounds per square inch; elongation in 2 inches, 18 per cent; bending test for 1-inch square bar, 180 degrees over 1½-inch mandrel. The tensile bars were 0.785 inch in diameter.

The steel made to these specifications gave the following results:

Chemical Results	Per Cent
Carbon	0.255
Phosphorus	0.037
Manganese	0.53
Sulphur	0.033
Silicon	0.259
Vanadium	0.190

Physical Results	*A*	*B*
Elastic limit, pounds per square inch	46,010	44,600
Tensile strength, pounds per square inch	75,820	74,420
Elongation in 2 inches, per cent	30.0	31.0
Reduction of area, per cent	43.3	43.4

I have given only a few representative results which we have obtained in meeting various classes of specifications, as I did not deem it advisable to take up any more of your time by giving a large number of results which have been obtained

in the many years that we have been making vanadium steel castings.

There is also a growing tendency to heat treat steel castings for many purposes, but so far we have not been called upon to treat our product in this way. Vanadium steel is much more suitable to heat treatment than ordinary steels, as it hardens more on quenching and consequently much higher physical properties can be obtained. Even air cooling from the annealing temperature, followed by annealing at a low temperature greatly increases the elastic limit without affecting the ductility. This is because nearly all the vanadium, being found in the pearlite in chemical combination with the cementite, exists as a compound, carbide of vanadium and iron in the case of ternary steels. This is due to its greater thermal stability, or power to withstand elevated temperatures without the softening, breaking down or separation of the cementite, as the vanadium-carbide is not as readily soluble on heating as iron-carbide.

In conclusion I would like to state that I believe that vanadium steel has been the cause of great improvements in locomotive and various other classes of castings, due to its toughness and greater power of resistance to dynamic and static ruptures. In short, in practical work it endows the steel with the quality of life.

Discussion

Mr. E. F. Cone:—I would like to ask whether these bars were machined to the sizes given and just how the bend was made and in what condition the steel was—whether it was heat treated—and where the bars came from?

Mr. J. L. Uhler:—The bars were taken from the castings. They were 12 inches long, 2¾ inches high and 2 inches thick. They were machined down and then ground and polished. The castings themselves were annealed to only about 1600 degrees Fahr., and the bar was then removed from the casting and machined. That is the entire treatment that was given. To get the bend, I had to have a die made. The regular bend-

ing apparatus that comes with the Olsen machine or with any other testing machine isn't sufficient to take care of a bend of this class. So, I had a block of steel cut out so as to give us almost the correct design of the bend. Then we had to have small rounds made so as to make the different degrees of radius, as 1½-inch, 2-inch, etc. The only treatment that was given to any of the steel was simply the ordinary annealing.

Mr. A. M. Henderson:—Is this steel basic open hearth or acid?

Mr. J. L. Uhler:—Acid.

Mr. A. M. Henderson:—Converter or electric, or acid open hearth?

Mr. J. L. Uhler:—Acid open hearth. We have a 25-ton furnace.

Mr. C. W. Rodman:—What percentage of vanadium was added in the ladle to give 0.19 per cent in your final steel?

Mr. J. L. Uhler:—No vanadium was added to the ladle at all. I do not approve of adding vanadium to the ladle. I have always added practically all the vanadium in the furnace with the exception of the fine material found in the keg, which very seldom runs over 25 pounds.

Mr. E. F. Cone:—I am very glad to hear you make that point. I presume you have some information about adding manganese. It seems to me very important to add the vanadium to the furnace even if the loss is a little higher, and for the same reason it would be necessary to add manganese.

Mr. J. L. Uhler:—Up to date I have always added all my manganese to the furnace. About half of our charge we put in the ladle, the manganese being ground to the size of a small hickory nut. If it is not ground that small, it doesn't go into the ladle. We have had what we call a hopper made that sits right over the runner. The gases which dry the runner play up against the hopper and preheat it. It has been about 12 months since we started to use the hopper. I find that the loss in vanadium isn't as great if the steel is worked properly. If the slag conditions are kept right up to normal, your loss isn't as great as the ordinary man thinks. We can put through the furnaces 0.22 per cent and take out anywhere from 0.18 to 0.185 per cent, giving us a loss of approxi-

mately four points, but in getting that I always use our vanadium scrap.

MR. E. F. CONE:—In the experience that I myself had at one time, we found that by adopting the process of marking vanadium scrap very carefully with a "V" or some distinguishing mark, and putting it into the furnace in vanadium heats, there was a considerable amount of vanadium recovered.

A Description of a Small Open-Hearth Furnace with a Few Reminiscences of Early American Steel Foundry Practice

By David McLain, Milwaukee

Owing to the constantly growing demand for light and medium-weight steel castings, a few remarks on a furnace designed to meet this demand should be of interest to every progressive foundryman. The writer believes it quite appropriate to include a short historical review of what he believes to be the first successful crucible steel foundry in America. Also a few remarks are presented regarding the pioneer steel foundryman, William Hainsworth, who was responsible for our idea of designing a small open-hearth furnace.

William Hainsworth, an Englishman, and practical molder, began experimenting in Allegheny, Pa., late in 1870. A year later he had proved to several gentlemen, among whom were Messrs. Irwin and Patterson, that satisfactory crucible-steel castings could be produced. The Pittsburgh Steel Castings Co. was formed. A modest plant was erected in November, 1871, at Twenty-sixth street and the Allegheny Valley railroad tracks, Pittsburgh, where the new concern began making crucible steel castings, melting the steel in "coke hole" furnaces of 30-pot capacity.

In 1877 fire destroyed the plant, but immediately a larger building was erected, in which two 24-pot gas-fired regenerative furnaces were installed. This outfit made its own artificial gas. These furnaces, in addition to the coke holes, more than trebled the output, although the coke holes were operated only intermittently.

Some Early Reminiscences

The writer entered the employ of this company November, 1877, as general utility boy. My duties combined carrying

Mr. Hainsworth's breakfast, with those of coremaker, errand boy, etc. I was soon given a molder's bench, at which were made plow-shares, stamps, shoes, dies and miscellaneous castings. The molders were paid $2.50 per day to make 50 plowshares and 6 cents each for any over, and it was no trick to make 10 to 15 extra.

I was only 14 years old at that time. I had access to Mr. Hainsworth's home and performed many little duties for him, therefore you will pardon this reference, if it leads you to believe I had a "stand in" with that gentleman. If this were not a body of busy men, a recital of many personal reminiscences about Mr. Hainsworth would be quite interesting.

But to return to the subject, the demand for steel castings increased from day to day, and in a few years the company was called upon to make large steel castings that would scarcely be attempted by crucible steel foundrymen today. Frequently they poured castings weighing from 7000 to 8000 pounds, requiring the entire furnace capacity of 70 to 80 crucibles.

On such occasions it was necessary to secure the assistance of outside "puller-outs" who brought their own tongs and leggings, in order to pull their share of pots, as speed was of the utmost importance. These men were employed at the Hussy-Howe plant, and were glad of the opportunity to earn $2 each for about 10 minutes' active work, drawing their share of 70 to 80 pots which were emptied into a bottom pour ladle. The metal was poured from the ladle directly into the mold.

Profound Shop Secrets

To the foundryman today, it may appear amusing to learn that great secrecy and caution were exercised in handling mixtures by those who duty it was to oversee this part of the business, and symbols instead of names were used to specify alloys for steel mixtures. For instances: *X* might represent "oxide of manganese", *XX* 80 per cent ferromanganese, etc.

Chromium and nickel were used by this firm in their crucible steel mixtures many years before the average foundryman was aware of their wonderful qualities when alloyed with steel.

The writer used nickel and chromium in producing "piercing balls", or "thimbles", as they were called, also rolls, for

the Elwood Weldless Tube Co., Elwood, Pa., when this concern first began the manufacture of its products. These parts had previously been obtained from Sheffield, England, at a cost of 40 cents a pound, but our firm made a nice profit at 25 cents a pound.

Next in importance were the facing sand mixtures, which were entrusted to an old German whose first name was "Andy",

FIG. 1—FRONT VIEW OF FIRST SMALL OPEN-HEARTH SHOWING CRUDE LADLE TACKLE

and woe unto the man or boy (except the writer) who tried to invade the shed in which the sand mixtures were made. Ground coke, crucibles and fire brick, mixed with loam and German clay were all used before it became known that silica sand was the best refractory. Molasses, glue and German clay diluted with water were used as binders and to wet-down the various mixtures.

In 1880 the Hainsworth Steel Co. was formed and a plant was built directly across the Allegheny Valley railroad tracks.

A bessemer converter was installed to make billet steel, but as the billet market fell off a few years later, the company commenced the manufacture of bessemer-steel castings.

In 1884, another bessemer vessel, 7 tons capacity, was installed in the old plant of the Pittsburgh Steel Castings Co. This was the first bessemer converter in the United States devoted exclusively to the manufacture of bessemer-steel castings.

In 1887 Mr. Hainsworth cast a gun of bessemer steel, and as he expected to revolutionize gun-making, it was a great disappointment to him, his associates and Pittsburghers in general, when it failed to undergo the test. He maintained that the test was not fairly conducted, and could not be coaxed into trying again. He also expected to cast projectiles, but the government tests were so severe it was not a profitable operation. One pin-hole would cause rejection. In 1890 the Hainsworth Steel Co. was sold to the Oliver Steel Co.

Great difficulties were encountered for many years while operating the 7-ton converter in the old plant, as a large number of molds were poured with only a jib crane to handle them and all the ladles of steel. All the castings had to be annealed, but it was noted later than the best converter metal when annealed was not the equal of unannealed open-hearth steel.

Mr. Hainsworth at one time anticipated a discontinuance of the crucible furnace, after he installed the bessemer, but he was disappointed, as the metal had neither the temperature nor fluidity to run light castings. This was very discouraging and at his home he frequently expressed the opinion that some man would design a small open-hearth furnace to melt one or two tons of steel for small castings.

Early Furnaces Short-Lived

Before and since then, many furnaces, ranging in capacity from one to five tons, have been built. They produced steel satisfactorily in much shorter time than was possible in larger furnaces, but in most instances the life of the furnace was limited owing to the burning out of the lining and roof. Relining these furnaces after a few heats increased the cost of

production to an exorbitant figure and the idleness due to these frequent shutdowns made the small furnace impractical, without a spare unit in reserve. This rapid burning out of the lining was attributed to the radiated heat from the walls and roof, which were greatly contracted in size, causing an enormous increase in the temperature of the furnace.

Mr. Hainsworth searched Europe for small furnaces to replace the crucible. He even brought several expert furnace builders to our plant who built furnaces, and, while constructing them, boasted about the quality of the product they would produce. But they all fizzled out, and we never succeeded in getting a heat of hot, fluid metal. Mr. Hainsworth was very firm in his belief that a successful furnace of this type could be built, and the best proof of this was that he brought these experts from Europe and spent thousands of dollars in an endeavor to do away with crucibles.

In 1896 a 20-ton acid open-hearth furnace was installed in a new plant that was built, piece by piece, always maintaining a portion of the old roof for the men to work under. The molders worked night or day, so as not to lose any time while dismantling the old building and the bessemer department, which was abandoned entirely.

No Demand for Annealed Castings

When the open-hearth furnace was about completed, a very capable melter from Chester, Pa., was engaged, who made good steel from the start. Although we had been making steel castings for 25 years, it was quite evident that the open-hearth steel was superior to the product of the crucible or converter, providing the same care was exercised in preparing the molds. We had eight annealing furnaces for crucible and converter castings, so were prepared to handle all kinds of castings, either large or small, but we seldom were requested to anneal the open-hearth steel.

There was a considerable reduction of defective castings of open-hearth steel used instead of converter metal in pouring the same patterns. This was especially noticeable in the castings which were most apt to crack when poured of converter metal.

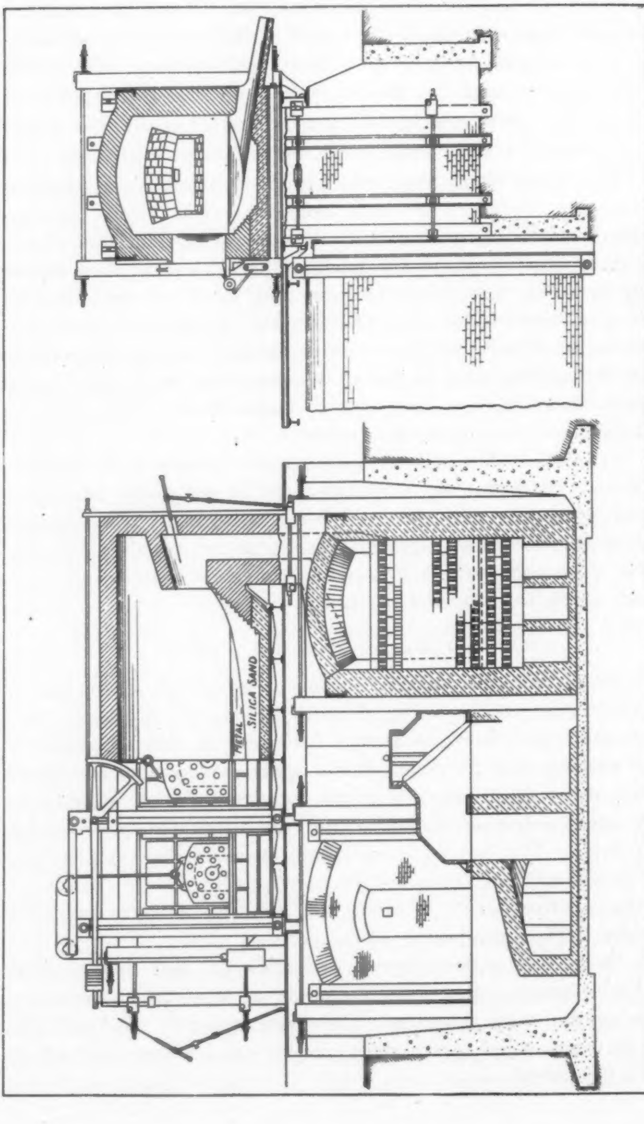


FIG. 2—GENERAL ARRANGEMENT OF SMALL OPEN-HEARTH FURNACE

We soon made new records which I believe have never been surpassed and seldom equalled since. Our losses were frequently less than 2 per cent on a year's run and were approximately 1 per cent for certain periods. Some months, the charges for returned castings amounted to only $20 to $80.

Mr. Carter, our first melter, frequently discussed with the writer the possibilities of designing a small open-hearth furnace, but before deciding on anything definite, Mr. Carter left Pittsburgh and it was not until he located in Milwaukee, a few years ago, that we decided on a design.

The First McLain-Carter Furnace

Drawings were made, and in December, 1915, we accepted a contract to build a 2 to 3-ton furnace for the Standard Crucible Steel Castings Co., Milwaukee. March 2, 1916, we melted the first heat, about 3000 pounds of metal. This firm was using 30 crucibles per day, at a cost of $5 each. They were scrapped after three to five heats.

The saving on crucibles alone paid for our furnace in 80 days. Our furnace will melt from three to five heats per day and barring some minor repairs, we believe, it will stand up for years, producing fluid steel of the very highest temperature.

The Standard Crucible Casting Co. had operated four crucible furnaces of the Milwaukee type for seven years, confining their product to castings weighing less than 100 pounds. Consequently the shop had no cranes, of either the jib or traveling types. An order was placed for a crane when they placed the order for our furnace, but the latter was operating for several months before the crane was installed. Great credit must be given the foundry executives for manipulating their scant equipment to take care of 6 to 10 tons of liquid steel per day.

To give you an idea of the crude manner in which the first heat was handled, permit me to digress for a moment. Overhead was an 8-inch wood beam to which was fastened a 6-foot length of a 1 x 3-inch flat bar. A block and tackle was suspended from this bar directly in front of tapping spout, as shown in Fig. 1. When the metal was tapped, it was found

the chains would not work either to raise or lower the ladle and we were compelled to *move the molds up to the ladle.*

Low Melting Loss

Melters and steel foundrymen in general claimed that this furnace would burn down in 30 days, but, strange to say, it melted 694 heats without relining. It also was contended that excessive oxidation would result on account of the shallow bath. The usual loss in open-hearth melting is from 8 to 10 per cent, and with good melting practice, we do not believe that ours will exceed 10 per cent.

Experience with our furnaces has proved, we believe, that in normal times it will melt steel at a cost of $22 to $24 per ton in the ladle, which is about half the cost of crucible steel in the ladle, when crucibles are selling for $2.25, with oil at 3 to 4 cents a gallon and boiler punchings from $14 to $16 a ton. We use standard bessemer pig iron and 85 per cent low-phosphorus scrap, unless a very low-phosphorus steel is wanted, when, of course, it is advisable to use some low-phosphorus pig iron.

The general arrangement of the furnace is shown in Fig. 2. This drawing shows a cross-section of the hearth, checker chamber and flue under reversing valve, and also an external view of the charging side of the hearth. One burner is shown in position for melting, while the other is withdrawn. The air chamber on the side, in which the burner is, is supplying hot air to the furnace, while the waste gases are storing up heat as they pass through the regenerator on the other side. The drawing shows the platform approximately 4 feet above grade. This is advisable when it is intended to wheel material onto the platform, otherwise the furnace and platform may be raised 8 feet above the floor, thereby dispensing with a concrete pit. Then, of course, an elevator is necessary.

Oil Used as Fuel

Oil is used as a fuel and when melting five heats per day, 70 gallons are required per ton of steel, although 65 gallons or less are sufficient when melting continuously. Afternoon heats of two tons each can be melted and poured in from 1 hour

and 40 minutes to 1 hour and 50 minutes, while the first morning heat may require 2 hours and 15 minutes to 2 hours and 30 minutes. Afternoon heats of 7000 pounds have been melted in 2 hours and 15 minutes, but the average time for a 7000-pound heat is 2 hours and 45 minutes. Several 8500-pound heats have been charged, melted and tapped in 3 hours or less in the afternoon.

While the claim has been made that a fire must be kept in this furnace continuously, whether it is working or not, permit me to state this is a mistake. It is true, we keep the furnace warm by using 40 or 50 gallons of oil every five or six hours to maintain a high enough temperature so the silica brick will be prevented from spalling, and to avoid undue contraction of the furnace. If for some reason you were not going to melt steel for a week or more, it would require approximately 200 gallons of oil each 24 hours to maintain the desired temperature. This furnace is provided with ample regenerators, apparently out of all proportion to its size.

Metal is Fluid

At least one heat per day of 4000 to 4500 pounds is poured over the lip and shanked for bench molds as in gray iron practice. Every steel foundryman who has been privileged to watch one of these heats poured has observed the fluidity of the metal. It will pour from 150 to 200 or more molds, some of which may contain 20 castings weighing only a few ounces each. The quality of the metal will depend on the material and care used by the melter. The foundry practice also must be good as in all other cases.

While one ton of steel may be melted per heat, at about half the cost of crucible steel, still we do not recommend a furnace built for 1-ton heats. The investment in a 1-ton furnace is too heavy. The investment, however, becomes doubly safe when you have a flexible unit that will melt one to five tons.

Discussion

MR. A. M. HENDERSON:—My home is in Australia. I am interested in small open-hearth furnaces for foundry purposes. I wanted to know if you had any information or had done any work on utilizing small furnaces of the type that you are using here on producer gas fuel?

MR. DAVID MCLAIN:—Not on this type, but in the early days in the Pittsburgh district we operated with producer gas. Then, being fortunate in being on the ground, we put in natural gas. When we got to the west we had to use fuel oil, and we learned there wasn't any comparison whatever between making steel with producer gas and fuel oil.

MR. A. M. HENDERSON:—You get better results with fuel oil?

MR. DAVID MCLAIN:—I think so. However, while all our small furnaces burn fuel oil, there is no question but what artificial gas or natural gas may be used as in other open-hearth furnaces.

MR. A. M. HENDERSON:—Can you give me some idea as to what the conversion costs are? Eliminate your raw material. That fluctuates too much; but give us the conversion costs with oil at a certain figure.

MR. DAVID MCLAIN:—It is $7.50 to $8.50 a ton.

MR. A. M. HENDERSON:—Does that include fuel and labor?

MR. DAVID MCLAIN:—Yes, sir.

MR. A. M. HENDERSON:—Overhead and depreciation?

MR. DAVID MCLAIN:—Yes, sir, and refractories.

MR. R. A. BULL:—I would like to ask what minimum section you are able to pour successfully with your furnace?

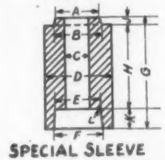
MR. DAVID MCLAIN:—We pour crucible sections at this time. We have poured ⅛-inch sections. There was not any area of consequence, but the sections were only ⅛-inch. We do not advise over a two-ton heat for small castings, which can be poured in 10 or 12 minutes. We learned by experience that that was about the limit, but our furnace will melt up to five

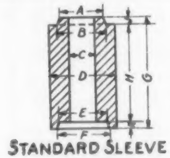
tons. In the plant of the Gas Traction Foundry Co., Minneapolis, on Sept. 14, we took down four 4-ton heats in 12 hours. Quite a bit of that work was in small castings. They pour all their molds in Minneapolis with bottom-pour ladles.

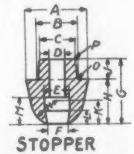
Mr. Lindberg:—I would like to ask what your melting loss is in the open-hearth furnace?

Mr. David McLain:—That depends on the melting. I will say from 8 to 11 per cent. Mr. Bull, what is the melting loss in your furnace?

Mr. R. A. Bull:—About 8½ per cent basic.







NAME OF FOUNDRY	SPECIAL SLEEVE A	B	C	D	E	F	G	H	J	K	L
AMERICAN STEEL	3	3¼	2	5½	2½	3½	9½	7	⅜	2	SQ
BETTENDORF CO.	3¼	3⅜	2 3/32	5⅛	3½	3⅝	9½	7½	½	1½	⅛
BIRDSBORO STEEL CO.			TAPER - SEE SKETCH								
BUCKEYE STEEL CO.	3¼	3⅜	2 3/32	5	3½	3½	9⅜	7⅜	½	1½	
BUCYRUS CO	2¾	2¾	1⅞	4	2⅜	2 9/16	8⅛	7⅜	⅜	⅜	
CLEVELAND STEEL CO.	2 9/16	3⅛	2 7/16	5	2¼	3¼	9	6½	½	2	⅛
COMMONWEALTH STEEL CO.			TAPER - SEE SKETCH								
DETROIT STEEL CO.	3	3⅜	2⅜	5⅝	2 7/16	3¼	9⅜	7½	7/16	2	
DUQUESNE STEEL CO.	2¾	3	2	4½	2⅝	3	8⅜	7	⅜	1	SQ
FALK CO.				NOT USED							
GOULD COUPLER CO.	3⅛	3¼	2⅛	5	2¼	3⅝	9½	7¼	½	1¾	
JONES & LAUGHLIN				NOT USED							
McCONWAY & TORLEY CO.	2⅝	2⅞	2	4	2¼	3	8⅝	7½	5/16	½	
MESTA MACHINE CO.			TAPER - SEE SKETCH								
OHIO STEEL CO.				"			"		"		
OTIS STEEL CO.	2¾	3¼	2	5	2¼	3¼	9½	8½	½	½	
PENN SEABOARD	3⅛	3¼	2	4½	3¼	3½	8¾	7 7/16	7/16	9/16	
SCULLIN STEEL CO.				SEE SKETCH							
STRONG STEEL CO.	3⅛	3 5/16	2⅛	5	2¼	3⅜	9¼	7¼	7/16	1¾	
UNION STEEL CO.			TAPER - SEE SKETCH								
WEST STEEL CO.				NOT USED							

NAME OF FOUNDRY	STANDARD SLEEVE A	B	C	D	E	F	G	H	J	K
AMERICAN STEEL	3	3¼	2	5½	3½	3½	9⅜	8½	⅜	½
BETTENDORF CO.	3⅛	3⅜	2⅛	5⅛	3¼	3½	9⅝	8 9/16	½	9/16
BIRDSBORO STEEL CO.	2⅝	3	2⅛	4	2¾	3¼	8⅜	7 7/16	7/16	½
BUCKEYE STEEL CO.	3¼	3⅜	2 3/32	5	3⅜	3½	9½	8½	½	½
BUCYRUS CO	2¾	2¾	1⅞	4	2⅜	2 9/16	8⅛	7⅜	⅜	⅜
CLEVELAND STEEL CO.	2¾	3 5/16	2 7/16	4 7/16	3	3½	9⅛	8⅛	½	½
COMMONWEALTH STEEL CO.	3¼	3¼	2⅛	6	3½	3½	8¾	7⅜	⅜	½
DETROIT STEEL CO.	3	3¼	1 13/16	5	3 1/16	3 7/16	9⅜	8¾	⅜	7/16
DUQUESNE STEEL CO.	2¾	3	2	4½	2⅞	3 3/16	8⅜	7 7/16	⅜	7/16
FALK CO.	2½	3	2	4¼	2½	3	9½	8½	½	½
GOULD COUPLER CO.	3⅛	3¼	2⅛	5	3¼	3⅜	9½	8½	½	½
JONES & LAUGHLIN	3¼	3	2¼	4½	3⅛	3⅜	9	7⅞	½	⅝
McCONWAY & TORLEY CO.	2⅝	2⅞	2	4	2¾	3	8¾	7½	7/16	½
MESTA MACHINE CO.	2⅞	3¼	2⅛	4¾	3 1/16	3 7/16	9	8⅛	⅜	½
OHIO STEEL CO.	2 9/16	2 7/16	2⅛	5	2⅞	3⅛	9⅛	8¾	7/16	⅜
OTIS STEEL CO.	2⅝	3⅛	2	4½	2¾	3¼	9½	8½	½	½
PENN SEABOARD	3⅛	3¼	2	5	3¼	3½	8⅞	7 7/16	7/16	9/16
SCULLIN STEEL CO.	3⅛	3¼	2¼	6	3⅜	3½	9⅜	8½	⅜	½
STRONG STEEL CO.	3	3½	2⅛	4 5/16	3	3½	9¼	8¾	½	½
UNION STEEL CO.			TAPER - SEE SKETCH							
WEST STEEL CO.	2⅜	2¾	1¾	4	2½	2⅝	8⅛	7⅜	⅜	⅜

NAME OF FOUNDRY	STOPPER A	B	C	D	E	F	G	H	J	K	L	M	N	O	P
AMERICAN STEEL	5⅛	3	2⅝	1⅛	2¼	1¾	5¼	4¾	1⅝	2⅛		2¼	2¾	SQ	SQ
BETTENDORF CO.	5	3½	3½	1⅛	1⅞	1⅝	5½	4	1½	1⅞	1⅛	2⅛	2⅛	⅛	⅛
BIRDSBORO STEEL CO.				SPECIAL - SEE SKETCH											
BUCKEYE STEEL CO.	5	3½	3½	1⅛	1⅞	1⅝	5½	4	1½	1¾	1⅛	2⅛	1⅞		
BUCYRUS CO	3⅜	2⅞	2⅜	⅝	1⅞	1⅞	4⅜	3½	1⅜			1½	1⅞		
CLEVELAND STEEL CO.	4½	3¼	2¼	1⅝	2⅛	1⅞	5½	3½	2		1½	1¾	1⅛	⅛	⅛
COMMONWEALTH STEEL CO.				SPECIAL - SEE SKETCH											
DETROIT STEEL CO.	4⅝	3⅛	2⅝	⅝	2	1⅝	5⅛	3⅝	1¾	2⅛	1⅛	2⅛	1½	⅛	
DUQUESNE STEEL CO.	4	2⅝	2⅜	1	1⅞	1½	4⅝	3¾	⅞	1½	1	1¾	1¾	SQ	SQ
FALK CO.	4¾	2⅞	2⅝	⅞	1⅜	1⅝	3⅝	3½	⅞			1¾	1⅞		
GOULD COUPLER CO.	5	3⅛	2⅝	1	1⅝	1½	5	3⅝	1⅜	3⅜		1⅞	1½		
JONES & LAUGHLIN	4⅜			1⅛	2¼	1⅛	4⅛					1⅞			
McCONWAY & TORLEY CO.	4⅝	3⅛	2⅝	⅝	1⅝	1⅝	4⅝	4¼	⅜	1½		2⅛	1½		
MESTA MACHINE CO.	4⅜	3⅛	2⅜	1¼	2	1¾	5⅜	4⅜	1	1⅝		1⅝	1⅝		
OHIO STEEL CO.	4⅞	2⅝	2½	1	1½	2½	6½	4½	2	2⅜		2⅜	1		
OTIS STEEL CO.	4⅝	3⅛	2⅝	⅞	1⅝	1⅝	4⅝	4¼	⅜	1¼		2⅞	2		
PENN SEABOARD	5	3	3	1	1½	1⅞	3⅝	3⅞	⅜	2⅝		1⅝	2½		
SCULLIN STEEL CO.	4½	3¼	2¾	1	2	1¾	4⅝	4	⅜			2⅝	2		
STRONG STEEL CO.	5¼	3¼	2¾	1	2⅛	1⅜	5⅜	3½	1⅝	2⅛	1	2	2⅛		
UNION STEEL CO.	4⅝	3⅛	2⅞		2⅜	1⅞	5⅜	3⅝	1¾		⅞	2	2⅞	⅛	⅛
WEST STEEL CO.	4	2¾	2¼	⅞	1⅝	1½	4⅛	3½	⅜	1	¾	1⅜	1¾		

DIMENSION IN INCHES

FIG. 1—DIMENSIONS OF SLEEVES AND STOPPERS IN USE AMONG VARIOUS FOUNDRIES

Report of A. F. A. Committee on Steel Foundry Standards

During the past year, the committee on steel foundry standards selected as its problem for investigation the standardization of standard sleeves, special sleeves and graphite ladle stopper heads, all of which is a sequel to the report on the standardization of ladle nozzles submitted at the Chicago convention in 1914.

The standardization of ladle nozzles has been of inestimable value to both users and manufacturers. In these stirring times of top-notch production, the assurance of being able to obtain a standard product, rather than to have to wait for the manufacture of special designs has been a source of incalculable value and satisfaction.

Your committee, this year, proceeded much along the same lines as the original committee, obtaining an expression from 30 or 40 steel foundries indicating their practices. We found widely diversified opinions as to what constitutes good practice in stopper-rod equipment design. We also found that in some instances this all-important function of ladle equipment has received little or no consideration.

Wall Thickness Insufficient

We found, in general, that the thickness of the walls at the base of the special sleeves is insufficient. With the varying degrees of burning on the part of the sleeve manufacturers, this thin wall is often underburned and very fragile, causing disintegration at the temperature of molten steel. This permits the steel to find its way to the stopper-rod pin, often resulting in the loss of a stopper head. We also found that many foundries use a stopper head with only a short wall offset of 3/8-inch. We believe this dimension should be increased to 1 5/8 inches to secure a better fit between stopper head and sleeve and a better alignment of the stopper head with the rod.

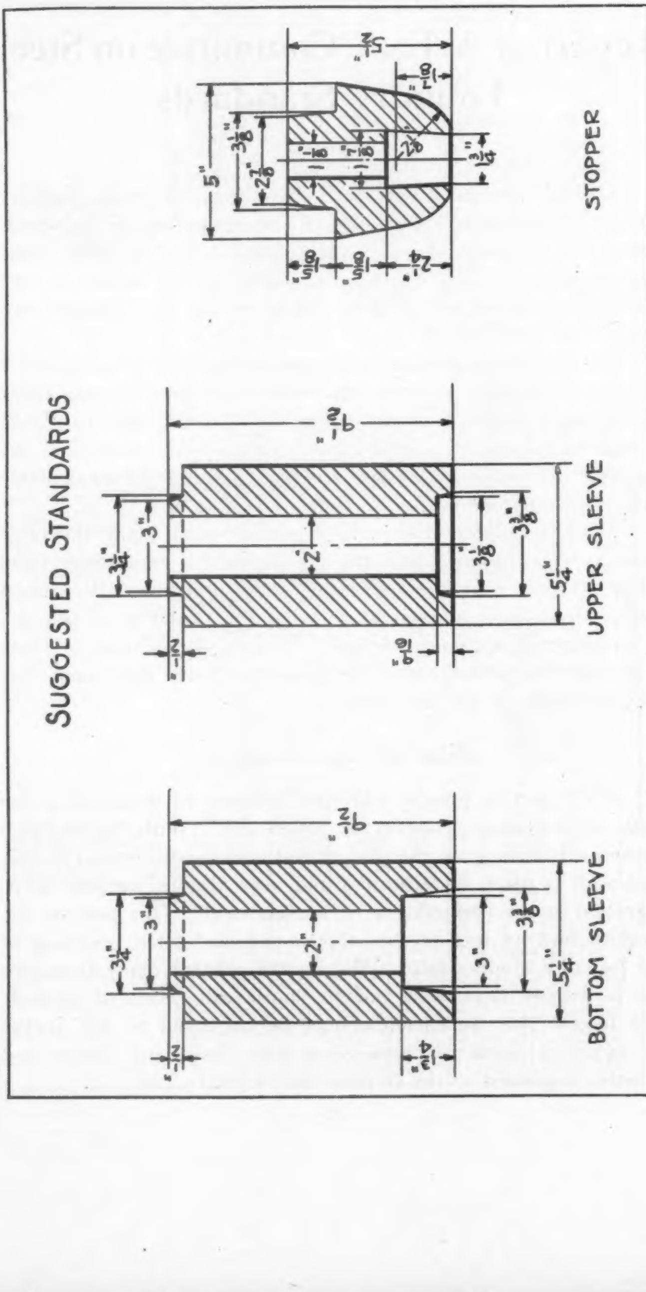


FIG. 2—SUGGESTED STANDARDS FOR SLEEVES AND STOPPERS

We also found that the dimension for the insert of the stopper head and the recess of the special sleeve was the same. To safeguard against variations in depth and unevenness in the bearing faces of the recess of the special sleeve, we have recommended that the depth of the recess be made 1/8-inch greater than the height of the stopper head insert. To make it certain that the total stress and shock will not be carried by the shoulder of the stopper head, we would suggest that a wadding or filler of clay be inserted between the top of the stopper head and the bearing face of the special sleeve.

We realize full well that the recommended standards are quite a departure from the past practices of many foundries. We, however, urgently solicit the trial and co-operation of all foundries in their adoption and use. Your committee has made no recommendations or specifications covering the character of the clay composition or the degree of burning. The refractory manufacturers are more familiar with the nature of their raw material and the required burning than we are.

A table covering a survey of the practice of various steel foundries and sketches showing the recommended standards are presented herewith.

W. A. JANSSEN, *Chairman*
L. A. WAY
RALPH H. WEST
FRED HENKE

Discussion

THE CHAIRMAN, MR. A. H. JAMESON:—It is moved and seconded that the report of the American Foundrymen's association committee on steel foundry standards be accepted and the specifications therein adopted. Is there any discussion?

MR. C. H. GALE:—In 1914, I believe, the association recommended a standard nozzle. We adopted it and have been using it ever since. One of the great advantages we have derived from it has been the ability to secure nozzles when

we wanted them, whereas we would have to wait a long time if we had special nozzles made up for us.

Mr. R. A. Bull:—It might be pertinent for me to say in this connection that a prominent manufacturer of stopper heads urgently asked me about two years ago to exert my personal influence to bring about a standard design of stopper heads, pointing out to me the difficulties from the manufacturers' viewpoint of taking care of the extraordinary number of designs that were in use at that time. I can readily understand his attitude would be representative of his industry.

Mr. J. L. Uhler:—The stopper as shown in the report is the one we have been using now for a little over two years. We have found it to have one or two virtues the old stopper did not have. You have fewer leanings of the stopper, which cause breaking off or missing the seat of the nozzle. It gives a greater length of shoulder, which you are able to protect by your sleeve brick. It is a more rigid stopper which is handled much easier by the ladle men. There are fewer leaks, which used to be more or less of a curse in our own plant, as well as in a great many other plants.

Mr. W. A. Janssen:—Mr. Chairman, I would like to call the attention of the members to the similarity between the special sleeve and the standard sleeve. The lengths are the same, their only difference being in the depth of the recess; and there are times when one has to be used in place of the other, and it can be very conveniently arranged.

The Chairman, Mr. A. H. Jameson:—All those in favor of accepting the report of the committee and adopting the recommendations, please signify by saying aye. Those opposed, no. It is unanimously adopted.

A New Method of Burning Crude Oil

By W. A. Janssen, Montreal, P. Q.

The first to appreciate the value of crude oil or petroleum distillate as a fuel was a Russian inventor who developed and patented a burner for crude oil in the early sixties. His device consisted essentially of a series of grates or griddles, over which the oil trickled, became ignited and burned. A year or two later an American inventor modified this original Russian method by utilizing a series of superimposed pans. The oil overflowed from one pan to another, the film or sheet of oil becoming ignited and burning. This form of oil burning apparatus is still used in many crucible furnaces even today. It is known as the Russian pan system. At about the same time a patent was granted in England on an oozing furnace. The bottom of this furnace was covered with a uniform layer of slacked lime beneath which was a series of chambers or vaults, through which the oil entered. On leaving the chambers the oil oozed through the slacked lime which served as a wick.

Another contemporary American patent covered the conveying of oil as a gaseous mixture; the oil was preheated, liberating the lighter oils which were subsequently consumed in the furnace.

First Spray Nozzle

The first spray nozzle was developed in America a few years later. From that time on there have been innumerable modifications of spray and jet burners. These burners in general may be divided into two classes, namely, high pressure and low pressure types. Aside from the pressure of operation, they also vary in design and construction, depending upon the atomizing agent used. These burners are dependent for their success on the use of air or steam as an atomizing agent. In addition some burners also have incorporated in their construction some form of spiral for mechanical atomization.

The spray burner consists essentially of a fan-shaped spray of steam or compressed air upon which a stream of oil is allowed to trickle, the oil being diffused or atomized and burned. The jet burners, of which there are many types, are so constructed that a stream of oil is swept into and becomes a part of a stream of air or steam, being atomized therein and subsequently burned. The spray and jet types of burners have their limitations, because of their inability to maintain a positive adjustment of the definite amounts of oil and air necessary to assure and produce perfect combustion. This

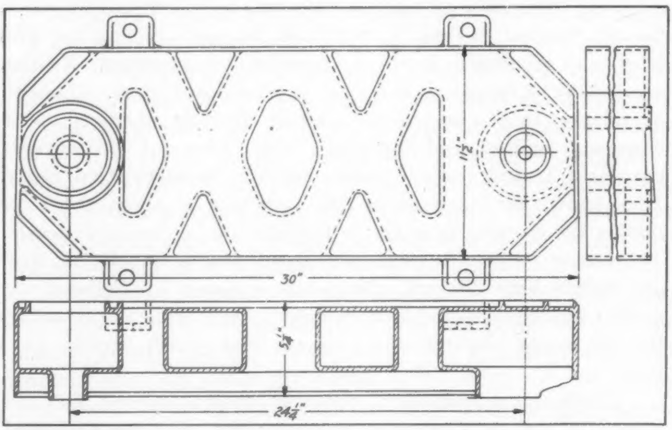


FIG. 1—GENERAL ARRANGEMENT OF CAST-IRON PREHEATER

condition is further aggravated by the use of oils of variable specific gravity, which congeal in cold weather. This makes perfect combustion almost impossible without the almost constant attention of the furnace operator.

Because of the inability to properly control the air supply to definite combustion proportions, the quantity of air is usually in excess of theoretical requirements for complete combustion, causing a reduced flame temperature. In the spray and jet types of burners, it is essential that there be an abundance of air in order to assure complete atomization and avoid smoking. If the burners are adjusted so as to admit a theoretical amount of air, the oil is not thoroughly atomized, resulting

in imperfect combustion, accompanied by excessive smoking and attendant reduction in flame and furnace temperature. The great objection to the present methods of oil burning lies in the fact that the vaporization and combustion are practically simultaneous and that both occur within the combustion chamber.

A New Apparatus

During the past year there has been developed a system of oil burning wherein the oil, instead of being atomized or

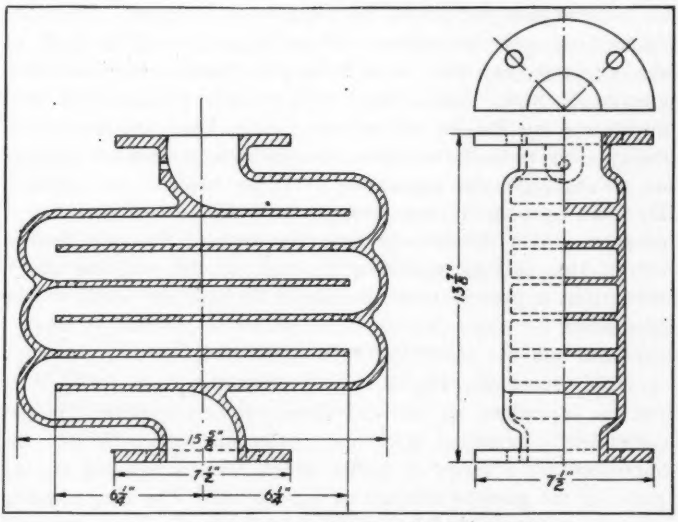


FIG. 2—DETAILS OF MIXER AND VAPORIZER

vaporized, is gasified in a specially designed vaporizer outside of the furnace. The gaseous product is forced into a combustion chamber under positive pressure with a resulting perfect combustion. This method of oil burning consists essentially of producing an oil-gas in a specially constructed vaporizer outside of the furnace proper, through the union of oil and heated air in definite proportions for perfect combustion. The air for combustion is delivered by a compressor at about two pounds pressure and a velocity of 150 feet per second. The air is forced to the vaporizer through cast iron preheater boxes placed

in the path of the out-going waste gases. With the admixture of oil in the vaporizer, a gaseous product is formed which is delivered to the combustion chamber under continuous pressure.

The cast iron preheater, Fig. 1, consists of a closed cast iron box with openings to connecting boxes for the admission of incoming air. A series of vertical flues are provided to permit the passage of the outgoing waste gases through the apparatus, thus providing a source of heat for preheating the air for combustion. The number of preheaters required is dependent on the oil consumption for which the furnace is designed. They are stacked one over the other, and are so placed in the path of the outgoing gases that their walls will transmit the maximum amount of heat. Each heater is provided with an inlet and outlet opening for the admission of air. They are located on the opposite ends of the heater, necessitating a complete passage of air through the apparatus. As the heaters are stacked, the inlet opening of one connects with the outlet opening of another. With this arrangement, the vertical flues are thrown out of line thereby retarding the flow of the outgoing gases, permitting a greater heat absorption through the walls of the preheaters.

Description of Vaporizer

The vaporizer, Fig. 2, is a hollow cast iron fitting. Its size is dependent on the calculated oil consumption. It has conveniently arranged inlet and outlet openings. Within the vaporizer are a series of baffles which form a winding zig-zag path for the gaseous mixture of air and oil. The long winding passage is essential for complete gasification. The preheated air enters the inlet of the vaporizer and commingles with the oil stream. On striking the first baffle, gasification is begun. The mixture of air and oil gas then winds past the succeeding baffles. It finally is discharged from the vaporizer through a pipe in the furnace wall leading to the combustion chamber.

If perfect combustion is to be attained, the proportions of oil and air must be right and the temperature of the preheated air also must be correct. The installation operates most efficiently when the temperature of the air is about 800 degrees Fahr. Allowing a temperature drop of about 100 degrees for radiation and the conversion of oil to gas, the net tempera-

ture of the gaseous mixture is about 700 degrees Fahr. The velocity of the gaseous mixture should be about 150 feet per second in order to prevent back-firing, or flame propagation in the direction of the source. This is most essential, as the temperature of ignition, 1050 degrees Fahr., is only a few hundred degrees higher than the temperature of the gaseous mixture, which in the proximity of the heated combustion chamber almost instantly is brought to ignition temperature.

Composition of Oils

The heavy fuel oils of commerce are practically all of the following composition: Carbon, 84.9 per cent; hydrogen, 13.7 per cent, and oxygen, 1.4 per cent. The Baume gravity is 26 degrees and the oil weighs 7.4 pounds per gallon. For perfect combustion, this necessitates about 3.4 pounds of oxygen or 14.5 pounds of air per pound of oil. This is equivalent to 180 feet of free air per pound of oil, or about 1500 cubic feet of free air per gallon. This may be more easily expressed as 25 cubic feet per minute per gallon per hour.

This method of oil burning lends itself very readily to every type of furnace in which the atomizing types of burners have been used. Oil economies of 40 per cent are not uncommon. A 10 per cent economy alone is effected in the preheating of the combustion air.

Discussion

Mr. A. M. Henderson:—Has the author had any experience in burning by-product coke-oven tar in burners of the type described in his paper? We have no oil in Australia but we have tars, and our production of tar is going to increase very much in the next few years. In burning tar it seems to me there is a possibility of clogging up the vaporizer by deposited carbon.

Mr. W. A. Janssen:—I have had no experience with burning coal tar; but another concern in the immediate vicinity of my plant had access to a considerable quantity

of coal tar and used it successfully by itself and also mixed, with heavy crude oils. They had excellent results. There is no carbon deposition on the baffles. The tar was used directly as it came from the gas plant without any refining at all.

The particular installation to which I referred when I first spoke was on a continuous annealing furnace about 70 feet long by 12 feet wide. It was really the equivalent of two former annealing furnaces 35 feet in length. In those two furnaces we used to burn 120 gallons of oil per hour. With this installation we burn 75 gallons of oil per hour. I had a similar installation, with some modifications, on a core oven. We reduced the temperature of the products of combustion to the desirable temperature for baking cores by dilution by the introduction of cooler air. We were able to control the baking temperature of the cores to within about 10 degrees.

The gaseous mixture as it comes from the burner pipe burns with practically a transparent flame. I can best describe it as being somewhat like the flame in a soaking pit furnace in steel mill practice. Thus far, I haven't used the installation on open-hearth furnaces, but I think it has some possibilities. It would have to be modified considerably.

All our experiments covered the use of oils varying from 24 to about 34 gravity, which, I believe, is practically within the range of commercial application. We used 34 gravity on a rivet furnace. We found that the rivets were more uniformly heated and we had a minimum of scale.

Notes on Electric Furnace Design

By JOHN A. CROWLEY, Detroit

A volume might be written on furnace design, yet in this paper I wish to touch but briefly on the mechanical and electrical characteristics of a one or 1½-ton furnace designed by the John A. Crowley Co., Detroit, for foundry operation. It is often difficult for a foundryman to appreciate the cost of building an electric furnace. A 1-ton furnace of any design will range in price from $18,000 to $29,000. The average foundryman considers this exorbitant. In discussing furnace design, one furnace operator remarked and very aptly so, "Give me a furnace of workable design, one easy to manipulate with good electrical characteristics and I will show you a furnace that will pay handsome dividends."

In choosing between a rugged, simple design and one that is more finished and complicated, good practice would recommend the former which will require little or no attention. Also should such a furnace break down, replacement can be made in much less time than on one of complicated design. The mere fact that no special attention need be given by the operator to the mechanical parts, that no delays occur because of breakages of furnace parts, is worth many thousand dollars to any foundryman, because delays cut down tonnage.

Cannot Be Too Rugged

From a mechanical standpoint it might be said that an electric furnace cannot be too ruggedly built, owing to the temperatures necessary in melting and refining steel. But more than this, the furnace should be as near fool-proof as possible, owing to the fact that skilled laborers, not only demand high wages but often are unattainable. Under present operating conditions in the average foundry, cheap labor must be used. The furnace, therefore, must be designed as regards its mechanical and elec-

trical characteristics so that it is impossible to make the smallest mistake in its operation. In case of a spill-out of metal, which may happen, the furnace must be designed so that the gears and motors will not be damaged.

Much attention has been given these details by furnace manufacturers in designing large furnaces. The Gronwall-Dixon furnace, shown in Fig. 1, was designed for foundries requiring from eight to 10 tons of molten metal per 24 hours. Fig. 2 illustrates the design of the tank and mechanical electrode control, together with the specially designed motor-tilting mechanism.

The tank is of the usual heavy reinforced plate, so built that furnace temperatures will not warp it out of shape. The charging doors and pouring spout are located at opposite ends. They are of a size to permit working the furnace front and back. The roof is not a part of the furnace lining, but is built in a special reinforced steel frame. This construction permits quick removal of the roof for occasional repairs. A spare roof may be easily set in place of the one taken out for repairs. The delay should not exceed 20 to 30 minutes.

Electrode Control

The electrode control is automatic. In fact, most successful polyphase furnaces are equipped with automatic control. Hand adjustment of electrodes, even when motor operated through a pushbutton station, slows up operation. Cutting the time of the melting and refining operation increases tonnage and increased tonnage means increased profits. It matters little how much the electrode control mechanism costs, if it pays a satisfactory dividend. The totally enclosed motors for the automatic control of the electrodes in this specially designed furnace are placed at the top of the superstructure and connected to a totally enclosed worm gear operating a screw which raises and lowers the electrode carriage through a traveling spider casting. The electrode superstructure in the 1-ton furnace is placed on one side of the furnace to facilitate quick removal of the roof for repairs. The electrodes enter the roof on a slight angle to increase the distance between electrode coolers and thereby lengthen life of the roof. The inside of the cruci-

ble is elliptical in shape and the ends of the electrodes are equidistant from walls, to maintain the desired melting efficiency.

The electrode clamps are water cooled, as are also the collars encircling the electrode at its point of entrance in the roof. The clamps, which are copper, are designed so as to permit quick shifting or removal in case of changing roof or

FIG. 1—POURING A 12-TON CHARGE OF ALLOY STEEL FROM A GRONWALL-DIXON FURNACE

repairing the furnace lining. The collars rest on the roof and are designed not only with a view to efficient cooling but to minimize escaping heat.

Tilting Device

The tilting device is similar to that used on larger furnaces, differing only in its mounting. In place of a rocker construction used in furnaces of 3 tons capacity and larger, the 1-ton furnace is mounted on trunnions swung in

A-frames. This construction does away with an expensive foundation and adds materially to the safety factor. The bottom portion of the A-frame is in a 3-foot pit below the floor line. The tilting motor is controlled through a reversing drum controller. In starting the motor, two pairs of connecting arms slowly straighten out, tilting the furnace forward through an upward movement. In handling metal in shank ladles, a slow, steady tilting of the furnace is essential. This is accomplished with this type of mechanical tilting device. This tilting mechanism is perhaps more expensive to build than others.

It would be very costly for the foundryman to have a heat of steel in the furnace and have something go wrong with the tilting mechanism so that it would be impossible to pour the heat. It is, therefore, only remotely possible to spend too much money on furnace construction. Should the heat of steel be chilled in the furnace it could be melted out, in fact this has been done in Gronwall-Dixon furnaces, due to no furnace difficulty, but to crane trouble which would not permit the handling of the ladle for removal of steel.

From a power station point of view a well designed polyphase furnace should have a power factor of 90 per cent or over and should give as near as possible a perfectly balanced load. The questions of current fluctuation and disturbances at the power station are most diligently inquired into by central station engineers. For this reason we have always advocated and designed furnaces with a neutral or bottom electrode, or with what is commonly called a conducting hearth. This hearth is not water-cooled and has no studs which come in contact with the molten bath but the entire hearth is conducting. A furnace so designed is believed to be more easily controlled than one without a neutral electrode, for the reason that any fluctuation of current in one or more of the upper electrodes is to a certain degree taken care of by the bottom connection.

When to Run Basic

Many arguments have been put forth in favor of acid operation and many electric furnaces are being operated acid. Cost is the chief consideration in determining operation of any

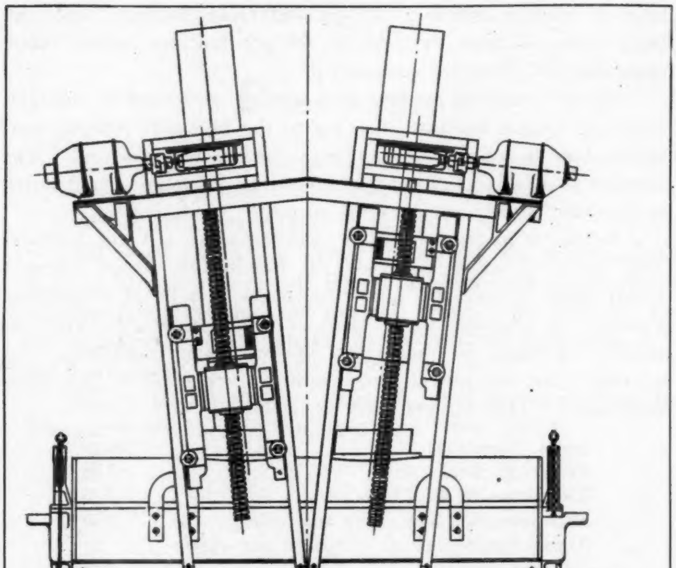


FIG. 2—PROFILE VIEW OF 1-TON FURNACE SHOWING AUTOMATIC ELECTRODE CONTROL AND MECHANICAL TILTING MECHANISM

type of electric furnace. If the difference between acid and basic scrap is more than $3 or $4 per ton, we believe basic operation will be more economical.

Many foundries today are making government material requiring special analysis. Owing to the fact that refining cannot be done on an acid bottom, basic operation is essential. The demand also for straight carbon steels has led many foundrymen to consider casting their excess metal in small ingots.

Below is given conversion cost data on a 1-ton furnace. The price of scrap is based on Pittsburgh prices current about Sept. 1 and the labor costs are based on conditions existing in Detroit about Sept. 1. These figures may be readily changed to meet any special local condition. An average rate for power the country over is $0.01 per kilowatt-hour. The figures are as follows:

Scrap (turnings)	$24.00
Power @ $0.01 per K. W. H.	7.00
Electrodes @ $0.075 per lb	1.35
Slag material, lime, spar and coke	0.30
Alloys (approximate) 4 lbs. 50 per cent	
Ferrosilicon	0.48
3 lbs. 80 per cent ferromanganese	0.59
1 lb. aluminum	0.65
Refractories (Basic)	0.45
Skilled labor melter $6.00, Boy $3.50	2.38
Unskilled labor, 2 men 40 minutes each heat to handle scrap and charge furnace @ $0.32 per hour	0.32
Cost of metal at the spout	$37.52

The foregoing costs are based on 24-hour operation with a minimum production of eight tons per day. This is conservative when one stops to consider that smaller furnaces of this design operating only eight hours per day have produced three heats of metal for castings.

Quite a personal equation enters into the operation of any electric furnace. An intelligent operator should equal and perhaps improve on the costs given above with this type of melting and refining furnace.

Discussion

MR. WILSON:—I would like to ask whether the hearth is conducting throughout the melting-down period.

MR. A. M. MINNICK:—It is.

MR. ARMSTRONG:—I would like to ask the reader of the paper if he can give us any figures to show how much current actually flows through the neutral. Now, just how he gets the circulation with a hearth that is connected all over, I do not quite know.

MR. A. M. MINNICK:—I haven't exact figures with me, but it is something like 4000 amperes on a 5-ton furnace.

Comparison of Electric Furnace and Steel Converter for Manufacture of Small Steel Castings

By C. R. Messinger, Milwaukee, Wis.

This paper may be interesting for the reason that it represents what has been done in fairly well operated foundries and not what the designers of electric furnaces think ought to be, or can be done. The following remarks are not written with the idea of presenting anything new on the subject of the electric furnace, but rather to give some figures and facts based on about 13 months operation on one furnace and 15 months on another. From the first furnace during this period 2029 heats have been taken, and from the second furnace 2436 heats. The furnaces referred to are single-phase, bottom-electrode furnaces. The furnaces have been run on an acid lining except for a period of approximately one month, when one furnace was run basic.

In the writer's opinion, it is going to be very difficult, if not impossible, to obtain satisfactory results from basic operation with this type of furnace. The single-phase bottom-electrode furnace operates with a long arc, which means high voltage. The heavy slag in connection with basic practice refracts the heat from the long arc to the roof and side walls and causes them to melt in a very short time. The chief difficulty, however, is encountered in putting in a bottom of dead burned magnesite or dolomite. A bottom of either of these materials should be sintered, and with a water-cooled bottom electrode this operation presents some difficulties. The electrode referred to is so placed that it projects through the magnesite, but cannot be used to form an arc with the top electrode to burn in the bottom for the reason that the bottom electrode is metal and thus easily melted. Should the electrode be melted too far, the

water chamber would be exposed and the results would be disastrous. It may not be quite fair to make the statement that it is practically impossible to run basic with this type of furnace, but these were the conclusions reached after a month's trial on one furnace.

Average Charge Over One Ton

The furnaces described are called one-ton furnaces, but very rarely is there less than 2300 pounds charged and for periods of a month at a time charges weighing 3000 pounds have been used. The average charge for the furnace making 2029 heats is 2529 pounds and that of the furnace making 2436 heats is 2780 pounds. An average charge on the first furnace is about as follows:

	Pounds
Contact Plug	25
Shop scrap, 50 per cent of which is heads and gates from converter castings	1200
Shrapnel ends or axle butts	500
Structural punchings	350
Forging scrap, including flashings	300
Turnings	100
Total	2475

The average additions per heat have been about as follows:

	Pounds
80 per cent ferromanganese	19.5
Ore	20.0
50 per cent ferrosilicon	13.5
Aluminum	1.0
Total	54.0

With this charge, steel can be made which will meet any specifications with which the ordinary foundry has to contend. The final chemical analysis, of course, can be varied by the final additions. The point which the writer is trying to bring out is that with the grade of scrap such as can be bought in

any market, it is possible to produce results satisfactory from a chemical and physical standpoint, on an acid lining.

During a period of 24 hours, it has been possible to melt and pour 12 such heats. Eleven heats during the same period is not unusual, but the best 30-day period shows an average of 9.24 heats per 24 hours. The melting time is approximately 2 hours and 15 minutes. The average charging time is 10 minutes.

Average Labor Cost

The average labor cost on a furnace of this type is $2.10 per net ton of steel melted and this figure covers bringing in the scrap from the yard, and as all repairing is done by the melters and helpers, this item is also included in this amount. The crew on the day shift consists of one melter, one helper and one man carrying scrap. The latter brings in enough scrap during 12 hours to supply the night shift also, so the night crew consists of one melter and one helper.

The consumption of electrodes on the furnace making 2029 heats in 13 months was 13,170 pounds, or an average of 5.15 pounds per ton of steel melted. In arriving at this figure breakage and a considerable amount of poor practice has been included. As graphite electrodes are worth approximately 13c per pound at the present time, the much talked of electrode cost amounts to less than 70c per ton of metal melted.

The cost which is generally considered first by the foundryman when considering the installation of an electric furnace is the cost of electric power used. This cost, of course, will vary according to the power rate and the kind of castings to be poured. The furnace described is used to pour very small castings with an average weight of less than four pounds; therefore, the furnace is not tapped until the metal is very hot and the power is left on longer than it would be in most foundries. The power consumption has averaged 635 kilowatt-hours per net ton of steel melted since installation. This figure is high for later practice and a figure of 570 kilowatt-hours can easily be made.

The refractory cost is more dependent upon practice than any other item, but even so, with ordinary skill can be fairly

well controlled. To illustrate this, a few figures from the furnace charts will be interesting. They are as follows:

Roof No.	Life of Roof No. of Heats
1	9
2	9
3	10
5	68
8	72
10	123
13	239
14	436
15	471
16	325

Since the melters have begun to appreciate the power behind the furnace, and eliminating the first nine roofs, the remainder show an average of 368 heats per lining. This resolves itself into a refractory cost of 7.8c per ton. Labor is not included in this figure, as it has been included in the melting cost of $2.10 per net ton melted.

Continuous Operation

Practically continuous operation can be maintained as the furnace does not have to be repaired oftener than once in six weeks, and by arranging for the shut-downs to come on Sunday, repairs can be started late Saturday and the furnace be put in shape to run again by Monday noon with an entire new lining and roof.

The maintenance of the electric equipment amounts to practically nothing and consists principally in keeping the switches clean. A plant having an electric furnace does not necessarily have to employ an electrician, as a little attention by the man who looks after motors, etc., will take care of whatever maintenance there may be.

It has often been stated that anyone could run an electric furnace and this, of course, is not true, as it requires a man with a good knowledge of metal. Of the four melters on these two furnaces two of them were converter blowers at the time the electric furnaces were installed. It can be said that any man with a good knowledge of metal can be taught to run an electric furnace in a very short time.

The writer has touched on practically all the items of cost which enter into making electric steel. It is apparent that the greatest variation in cost of making acid electric steel will come from the purchase price of scrap. However, the classes that can be used are so numerous that a reasonably low-priced mixture can be obtained in any foundry center. The reason for the miscellaneous mixture previously given is primarily to obtain a uniform analysis, as by using a number of different grades, when one car is finished, the substitution of a new car does not materially change the analysis. However, the question of the selling price of various grades of scrap has been taken into consideration in making up the mixture.

The power cost is next in importance as an increase in the power rate of ¼c per kilowatt-hour will show an increase in the cost of castings of $2.65 a net ton, using a casting yield of 60 per cent and the average kilowatt-hour consumption mentioned above. The plant with a rate of ¾c per kilowatt-hour will have an advantage of very close to $8.00 a ton in the cost of finished castings over the plant with a rate of 1½c per kilowatt-hour. The rate which the power company gives is important, but it is just as important, if not more so, that the central station be equipped to handle the load properly and give continuous service. It seems to work out in practice that the central station which does not have an excess of power cuts off the electric furnace load first when conditions arise where enough power cannot be furnished to meet all demands. It is also important that the rate be based on some schedule so as to give the plant the advantage of a lower rate when it furnishes a power company with a larger and more continuous load. In other words, a plant should have some consideration in rate for continuous operation to offset the disadvantages of night pouring.

The labor cost, the maintenance, the electrode and refractory cost should be approximately the same in all localities.

Good Results on Small Work

The operation of the furnaces mentioned, one of which is run in conjunction with the side blow converter, shows that better foundry results are obtained in pouring small work with electric steel rather than converter steel. While it is possible

to obtain any degree of temperature this side of the melting point of silica brick in the electric furnace, it is not difficult to obtain an even temperature over a number of heats. In pouring large work the advantage is not so apparent, but it very often happens that when the foreman has a large intricate casting to pour, one which might crack, he frequently requests that it be poured in electric steel. This is not an important fact, but it shows the attitude of the men who are dealing with both kinds of metal day in and day out.

The present market price of low-phosphorus pig iron is such that a comparison of costs between the electric furnace and the converter is of little value. However, foundrymen are interested in the subject, as it has been claimed that the electric-furnace metal in normal times could be produced at a much lower cost than converter steel and as cheap as open-hearth steel. Enough figures have been compiled to show that in normal markets this statement is not entirely correct. Using the normal price of low-phosphorus pig iron, scrap, coke and a power rate which can be obtained in most large cities, the figures show that the electric furnace has a slight advantage so far as costs are concerned when compared with the converter. In making this comparison, the high original cost of the electric furnace has been kept in mind and the question of investment and depreciation has been considered. The comparative figures are so close that were the pig iron used in making the comparison put on an f.o.b. Philadelphia basis, the slight advantage would be with the converter.

A fact which may have a bearing on this subject in the future is that at present low-phosphorus pig iron is being produced in this country at a rate of 560,000 tons per year, whereas the production prior to 1915 was approximately 300,000 tons. It is just possible that this increased production will in normal times eliminate part of the premium that has been paid for low-phosphorus over bessemer iron. A change in conditions such as this would bring the two methods practically on an equal basis.

The situation sums itself up, that the farther west a plant is located the better comparative cost the electric furnace will make because of the freight rate on low-phosphorus pig iron and that

there are certain points in the east where the question of an installation of an electric furnace rather than a converter would have to be determined on the basis of whether or not there was any difference in the quality of the metal produced.

One of the furnaces referred to in this paper is operating in the plant of the Sivyer Steel Casting Co., Milwaukee, and the other in the plant of the Electric Steel Co., Chicago.

Discussion

Mr. R. H. West, of Cleveland:—I am interested in Mr. Messinger's record of the life of the roofs. It shows the practical end of the installation and operation of electric furnaces is more important than the engineer's end. When you started up, didn't you have an experienced man with you for a month or two to watch the roof proposition?

Mr. C. R. Messinger:—Yes, we have had an experienced man with us, but possibly you have had some experience in installing new equipment in your plant. We had a man who knew how to melt electric steel, but he couldn't do particularly well in our plant. I do not think that was entirely up to him, either. I think it was just a new set of conditions. That is true not only of electric furnaces. When we started our converter, the first day we dropped four blows.

Mr. C. W. Rodman:—How do you set your acid bottom in the first place?

Mr. C. R. Messinger:—With ganister and binder. We burn it.

Mr. C. W. Rodman:—That burning is what interests me.

Mr. C. R. Messinger:—We start off with a wood fire and then follow by putting in coke. Then we bring in an air line, and get it down as near to the bottom as we can and get a very hot coke fire.

Mr. C. W. Rodman:—Thank you very much.

Mr. A. M. Henderson:—I am interested in the water-cooled bottom electrode, and am rather anxious to know if

you have had any unfortunate experience with explosions caused by getting into your water jacket. I am also interested in the absorption of silicon from the silicious lining of your vessel. Is that absorption of silicon controlled or not?

MR. C. R. MESSINGER:—Yes, we have had two accidents resulting from the bottom electrode. The first one put one man in the hospital. The second one, which was in Chicago, put three men in the hospital. That is an unfavorable feature of that furnace, but wouldn't necessarily condemn it. There again, it is a question of practice. Our men, in both cases, had to have an accident to show them they were playing with fire. We have repeatedly warned them to not burn their bottoms down, but in a spirit of making a record they burned the bottom down too far. If you burn it down too far, with the water-cooled electrode, you can't tell what is going to happen. In one case, the roof went off; in the other the metal went out through the doors. The first accident we had was over a year ago. We have had no sign of an accident since then.

We had considerable trouble on an acid lining in maintaining a uniform silicon when we started. That, again, is a matter of practice, and I couldn't tell you any one thing that has overcome this trouble; but we can get silicons just as uniform now with an acid lining as you can with an acid open hearth.

The Electric Furnace from the Central Station Viewpoint

By Edwin L. Crosby, Detroit.

Probably no instrument for the use of electrical energy for industrial purposes, other than the induction motor, has caused as much interest among both central-station operators and their patrons as the electric furnace, particularly in its application to the steel industry. Arriving as it did to that state of development which allowed its installation as an economically practical piece of apparatus simultaneously with an unprecedented demand for the very materials to the production of which it was most suitably adapted, the electric steel furnace has come in for very exhaustive consideration by the various individuals, manufacturing companies and societies interested in the production or sale of either steel castings, electric steel furnaces, or electrical energy.

Up to the present time approximately 200 steel furnaces of various types having an annual capacity of about 1,200,000 tons of steel have been installed or contracted for on this continent. This steel production involves the use of approximately 750,000,000 kilowatt-hours per year. Thus is the very healthy interest of the aggressive central station man in the problem justified.

Errors Have Been Made

Naturally in the attempt to secure all the new business possible by the use of electric furnaces, many concerns both in the steel castings trade and central station business have made serious errors. Many steelmakers and foundrymen have installed furnaces which for various reasons were utterly unsuitable for their use. Also many central stations have listened to the luring tales of various highly estimable furnace salesmen and permitted, even urged, the connection of furnaces to their lines,

the operation of which was fatal to the happiness and peace of mind of the entire production department of the stations concerned. Beautiful visions of regulation equivalent to that of a lighting load, perfect phase balance *et cetera* have become nightmares of despair to not a few of the power companies of the country. Others have quoted rates for this class of service inconsistent with the characteristics of the load with rather disastrous results to their balance sheet.

To avoid unnecessary repetition of such occurrences it is essential that a closer study of the adaptability and operating characteristics of electric furnaces in general and the more common types of steel furnaces in particular be made by foundrymen contemplating the installation of such apparatus as well as by the central stations from which the foundrymen are likely to purchase power.

Has a Right to Advice

Any foundryman has a right to expect intelligent advice from his local central station on the electrical characteristics, their advantages or disadvantages, of any electrical equipment he may contemplate purchasing.

Central stations certainly stand ready to advise a storekeeper as to the best form of lighting equipment for him to use; they also are prepared to tell the power consumer which type of motor is best fitted for the particular purpose under consideration. An aggressive, wide-awake central station engineer is even able to advise intelligently upon problems involving various types of refrigeration equipment, valve gear, of air compressors, etc., giving due consideration to their effect on the customer's "demand", energy consumption, etc., and the consequent rate he would earn.

By the same token, the central station anticipating electric-furnace business should be prepared to discuss intelligently with the buyer of an electric furnace the electrical and metallurgical characteristics of the various types offered for sale. The power salesman must have a fairly good understanding of the metallurgical practice involved before he is able to give dependable data on the electrical performance of any furnace as these two matters are very closely related. For instance, an electric steel furnace

connected to a large power system capable of handling large blocks of energy may be operated with less regard to fluctuating power input than if it were connected to a system of which constituted a large proportion of the total load.

Take a specific case—melting and refining cold scrap for small steel castings. The only limiting factor in the rate of current input during the melting period seems to be the effect upon the customer's demand. The scrap has an infinite capacity for absorbing heat, the refractories will not be injured, the radiation losses per heat are decreased and the electrical equipment, if properly designed, can stand considerable overload during this period, if it is really desirable to increase the rate of energy input. When refining, however, a much lower rate of heat, hence energy, input may be desired, perhaps only that rate necessary to maintain the temperature already acquired until sufficient time has elapsed for the desired chemical reactions to occur. It would seem, therefore, desirable to operate with a much higher arc voltage during the melting period, decreasing the potential when the bath becomes fluid and refining is begun. It is entirely possible that such a method may result in a lower cost of power per ton. Quite certainly it would result in a lower current consumption per ton and if carefully controlled, an extra heat per day is easily obtained. Balanced against the increased demand charge per ton of metal are lower overhead charges, lower labor charges, lower radiation and electrical losses and general increased operating efficiency.

Co-operation is Needed

Here is where it is quite necessary for the central station man to assist the furnace user in determining the most economical point for operation. The method of determining demand and greater current fluctuations upon the distribution system are important factors in the determination of this point, and require a fair degree of familiarity with electric-furnace practice as well as with the central-station rate schedule.

In this connection, it is the writer's sincere belief that there is considerable opportunity for standardization of demands by the central stations of the country. It does not seem reasonable that local conditions are sufficiently diverse to account for

the extremely variant methods now employed by companies selling service under relatively similar conditions.

While the cost of power per ton of steel produced is of course important, being one of the greatest tangible items in the cost sheet, the writer has visited several electric-furnace installations where power cost seemed to be the paramount issue, while in reality a lack of superintendence and generally loose organization ran up charges far in excess of any reasonable power cost. As a matter of fact, industry in general is rapidly awakening to the fact that with the present greatly increased cost of labor and material together with a very slight (if any) increased cost for electricity, the power cost of most any article manufactured is not as important as formerly was the case.

Heretofore, the greatest item for consideration among central stations desiring an electric-furnace load has been the power factor. There is no occasion for unrest upon this point at the present time, as very careful investigation of several furnaces of various types has shown that with the possible exception of one type of arc furnace, and the certain exception of the induction furnace, all steel furnaces on the market today, if properly installed, will operate with a power factor of 0.80 to 0.85 during the early stage of the melting period, later rising to 0.85 to 0.90, and finally to a point as high as 0.95 or better during the refining period.

May Have a Leading Power Factor

Inasmuch as single-phase arc furnaces should never be connected to polyphase systems except through phase converters, while induction furnaces operate more satisfactorily at frequencies below those in general use, thus requiring frequency changers, either of these types, thus equipped, may be connected to a polyphase system so as to impose unity or even a leading power factor.

Regulation, phase balance and wave distortion have not, on the other hand, received the attention they undoubtedly deserve. Present electrode regulation is at the best very unsatisfactory, it being impossible with any existing equipment to obtain sensitive regulation without considerable hunting of electrodes and

disturbance of phase balance. If it is proposed to connect an electric furnace to a network properly designed to satisfactorily operate under existing conditions and with existing load, very careful consideration should be given to this point of regulation, and it may be advisable that carefully selected reactances be placed in the furnace circuit.

Recent oscillographic investigations have shown a very marked distortion of the current wave in all types of arc furnaces. This subject is a very important one as it may affect the accuracy of induction type watt-hour meters. Large wave distortion is also detrimental to the operation of other apparatus connected to the system, for instance, lowering the efficiency of rotary converters.

At first thought it may seem that such subjects are irrelevant before a foundrymen's meeting, but the writer wishes to call attention to the fact that it is necessary for a public utility serving any particular class of business to charge back to that class any expense contingent upon the service; so that if in order to superpose upon existing systems, satisfactorily operating any new form of load, it becomes necessary to increase the investment to an abnormal point, that investment must be reflected in the rate charged for the new class of business.

The writer does not wish to pose as an alarmist, nor does he believe that in the large majority of cases any such fears need be serious deterrents, but when a central station operating a transmission system of considerable length with somewhat limited capacity in generating and distributing equipment connected, attempts to take electric-furnace business, especially at rates based upon existing conditions, it is quite likely to get into serious difficulty which may later cause the station, as well as the furnace user, deep regret.

Should Offer Unprejudiced Opinions

For the reasons mentioned it is obvious that the representative of a central station anticipating electric furnace business, should thoroughly familiarize himself not only with the operating characteristics of various types of electric furnaces, but also with his customers' requirements, and after careful consideration should offer an unprejudiced opinion upon the relative

desirability of the various furnaces obtainable. It may be good judgment to advise against the electric furnace installation entirely. This was the writer's experience upon two occasions recently. Two customers having more or less scrap to sell and experiencing the universal difficulties in steel deliveries contemplated the installation of electric furnaces to supply their demands. After considering the investment, delivery on furnace and electrical equipment, the uncertainty of the market both during and after the war, the customer in each case was unhesitatingly advised not to make the installation. Incidentally, I believe any central station who urges the installation of electric furnaces for steel based upon the present market may later have cause for regret, unless he receives a rate commensurate with the risk.

The central station and the steel manufacturer have to consider from different standpoints the conditions peculiar to the present time, in deciding whether the investment in an electric furnace or the investment in the power plant and transmission necessary to supply that electric furnace should or should not be made. The steel manufacturer may be able to recover his entire investment by the sale of his output at high prices in a war time market which cannot get enough high-grade steel, whereas the central station is required by financial methods, and in some cases by law, to treat all of its investments as permanent, or if not permanent to be amortized over a long period of time, and is further required to have its rates for all classes of service consistent with one another. Therefore, the central station is compelled to consider the future of the steel market, the permanency of the service and the possibility of selling its capacity to some other industry in case the steel furnace should cease to be profitable to the manufacturer after the normal market conditions are restored.

Perhaps the demand for high-grade alloy steel for new uses after the war will keep all the electric furnaces busy. Perhaps the increased cost of labor and fuel will operate against the open-hearth or other less efficient processes sufficiently to allow the electric furnace to compete in ordinary tonnage production. The central station certainly hopes so. But meanwhile any installation should be carefully considered.

Such advice at this time is perhaps superfluous, as it is doubtful whether deliveries on electric furnace equipment are attractive enough to cause any great interest.

Should Compete Successfully

As stated in the report of the electric steel furnace committee to the National Electric Light association this year, that body believes that the electric furnace should supplant or successfully compete with the crucible or converter processes for any purpose. It should, given usual freight differentials, supply local markets with the equivalent of the higher grade open-hearth material, local scrap markets being favorable. However, under normal conditions the committee did not feel that the electric furnace was a competitor in tonnage steel.

In the steel castings trade there appears to be no reason why the electric furnace, when thoroughly developed, should not supplant practically all other methods in foundry use. By close co-operation between foundrymen and the central station people that development can quickly be carried to completion. We may reasonably hope to realize that long anticipated ideal which I once heard stated at a meeting of this society by a representative of a competitor of the electric furnace, namely: "The electric furnace method is the *ideal* method for making *ideal* steel." The central station is willing to do its part.

Discussion

MR. BOYDEN:—While Mr. Crosby touches upon the single-phase furnace, he indicates, in his opinion, that the three-phase furnace is going to be the coming furnace, but I would like to ask how the single-phase furnace is supplied by the central station from the multi-phase lines?

MR. C. F. HIRSHFELD:—Where furnaces are very small, they might be connected like any small single-phase motor. The practice of companies differs. Some, for instance, will connect a half horsepower single-phase motor, but nothing

larger. Others, I believe, connect as high as 2½ or 3 horsepower motors. That doesn't come anywhere near to the size of single-phase load commonly considered when talking of steel furnaces. I believe there are some companies, however, who have connected single-phase furnaces to their lines, hoping that they might be able to balance between phases by connecting other single-phase loads. The solution of the problem, if its persists, will probably lie along the line of what we might call the use of an intermediate rotary machine, which works practically in this way: It motors using three-phase current, and it generates single-phase current, drawing upon the two phases which would be unused otherwise, for the supply of practically two-thirds of the total amount of power. Both of the larger builders of electrical apparatus in this country are ready to supply equipment of that kind. Does that answer your question?

Mr. Boyden:—Not exactly. I intended to inquire more particularly whether single-phase furnaces were operated satisfactorily by static transformers, either with some modification or Z connection.

Mr. C. F. Hirshfeld:—All I can say is that I know of none.

Mr. F. T. Snyder:—I want to say in regard to this question of educating the customer that in Chicago, the Commonwealth Edison Co. has gone to a great deal of trouble to try to educate one of its customers who has two single-phase furnaces. The company pointed out very clearly where the customer could save $200 a month. Six months have gone by and it has been impossible to get the customer to save the money, for the simple reason that he deals with human melters and he cannot get them to do what they are told.

Recent Developments in the Application of the Electric Furnace to the Melting Problem

By Douglas Walker, Chicago

Sentiment in the steel foundry industry toward the electric process had undergone a radical change at this time a year ago. The period of skepticism and criticism, of experiment and doubt had largely passed, and the electric furnace was beginning to receive general acceptance. Another radical change has taken place during the past year.

In the past, the steel founder has had to rely largely upon the claims of the various electric furnace manufacturers. During the past year, the rapidly increasing knowledge of and data regarding electric furnaces have practically eliminated such a condition. Today the steel founder considering the purchase of electric furnace equipment investigates the electrical and mechanical details of each furnace just as closely as he would investigate a molding machine, an air compressor or any other piece of standard equipment. He knows that there are certain difficulties that must be avoided and that there are certain almost standard efficiencies that must be secured. He selects the furnace that avoids the difficulties and obtains the efficiencies. A year ago it would have been regarded as bad judgment for a steel founder to purchase an electric furnace that was entirely on paper with no units installed. Yet this is being done today, and the risk is minimized, because the steel founder knows that certain combinations are bound to give certain results, if carried out by engineers who are thoroughly conversant with electric furnaces. The electric furnace is today accepted as a standard type of melting equipment, and a steel founder who buys an electric furnace does not buy because of claims and with the fear of experiment; he buys on the strength of the known value of

given combinations of features. When any equipment has reached this stage, it has definitely arrived.

Electric furnaces today are in commercial operation in foundries for the following purposes:

1.—Melting steel scrap.
2.—Refining molten steel.
3.—Melting and refining steel scrap.
4.—Melting gray iron.
5.—Melting malleable iron.
6.—Melting ferromanganese and other ferroalloys.
7.—Melting copper and copper alloys.

The common use of the electric furnace in the foundry, is for melting down steel scrap for the production of steel castings. The superior qualities of steel castings thus produced, when properly made, have been demonstrated in too many ways for it to be necessary to go into detail here. In an increasing number of foundries the electric furnace is used for the melting and refining of steel, where an extra high quality of steel is desired, low in phosphorus and sulphur, meeting definite specifications. The Canadian and United States governments are both installing a considerable number of electric furnaces for this purpose, the chief object being the production of steel low in sulphur.

The refining of molten steel taken from bessemer or open-hearth furnaces is not common to the foundry. This process is chiefly found in large steel plants and electric furnaces so employed are usually of larger sizes than are employed for melting down cold scrap.

Electric Melting of Malleable Iron

There has been much talk of the adaptability of the electric furnace for melting malleable iron. It is the contention of many, and a very plausible one, that the silicon and carbon, the important elements in malleable iron, can be more closely controlled in the electric furnace than in the air furnace. Furthermore, it is manifestly possible to hold the heat in an electric furnace whereas in the air furnace the heat must be poured as soon as it is ready. It is also possible to keep the metal up to heat in the electric furnace, while shanking. Malleable iron has been melted in some few cases in electric furnaces, but there is practically no reliable information regard-

ing the results available. It is the opinion of the writer that before long there will be considerable data available regarding the melting of malleable iron in the electric furnace, and that eventually the application of the electric furnace to this work will be as important as it is in the steel founding industry today. The ability to use lower priced scrap materials for the production of malleable iron in the electric furnace will have an important bearing, as it has had in the melting of steel.

The electric furnace cannot compete commercially with the cupola for melting gray iron. The use of the electric furnace for producing a specially high-grade gray iron, however, has not only been considered seriously, but carried out commercially. The Daimler Motor Car Co., Coventry, England, installed a small electric furnace for the production of a high-grade gray iron for use in aeroplane motor cylinders, and shortly after starting the first unit, placed orders for additional electric furnace units for the same purpose. It is believed that the use of the electric furnace makes a more suitable iron for such cylinders, due to the fact that the sulphur content is kept down, that the metal is melted under conditions ideal for the production of iron free from air holes, and that the iron produced in an electric furnace has the same density that is characteristic of electric steel. There is no doubt that in the electric furnace, by keeping down the sulphur, a higher grade iron can be produced continuously than is now produced in the cupola. The entire matter comes down to a question of commercial practicability; that is to say, whether the higher quality of product justifies the considerable initial investment required and the higher operating cost. In melting gray iron in the electric furnace, the ability to use scrap material will probably feature in reducing the difference between the cost of melting in the cupola and in the electric furnace.

The use of electric furnaces for melting ferromanganese is gaining ground, particularly in large steel plants operating a number of open-hearth furnaces. Ferromanganese can be melted in an electric furnace with comparatively small loss of manganese, provided proper slags are employed. One big steel plant installed a one-ton holding capacity electric furnace for melting ferromanganese for additions to the open-hearth ladles.

It was their belief that by adding the manganese in a molten state instead of cold, they would reduce the quantity of ferromanganese necessary for deoxidizing the steel by approximately one-third. On such a basis, a furnace would pay for itself in less than a month's time under present market conditions. In this connection, it is of interest to note the results obtained in melting down manganese steel scrap in the electric furnace. The manganese steel scrap employed contained from 12.25 to 12.50 per cent manganese. When molten, and before adding more ferromanganese, the metal contained 11.50 to 11.75 per cent manganese, showing a loss of manganese of less than 10 per cent.

The use of electric furnaces for melting of non-ferrous metals has not advanced sufficiently as yet to permit of definite statements. For melting brasses and bronzes, furnaces of the direct arc type, indirect arc type and the induction type are employed today. The induction and resistance types of furnace are theoretically the ideal furnaces for this kind of work from the standpoint of minimizing losses. The induction type has the disadvantage that for practical operation it should be worked continuously 24 hours per day, and this does not fit in with the usual practice of brass foundries. The resistance type is apparently very satisfactory for the melting of nonferrous metals.

Acid or Basic?

One of the primary questions of the steel founder today, when considering the installation of electric furnace equipment is whether to operate acid or basic. This is a matter entirely dependent upon local scrap conditions and upon the character of product to be produced. The acid process is the simpler operation and requires less technical supervision. On the other hand, with the acid process, it is necessary to use a scrap sufficiently low in phosphorus and sulphur, and there is not the flexibility for producing castings of special analysis that is possible with the basic process. It is the writer's belief that under present market conditions, particularly, electric furnaces for the production of steel castings should be operated basic, irrespective of the comparatively high cost for basic refractories. This opinion is based on the fact that there is today so wide a

margin between the cost of the higher grades of scrap for acid melting and the lower grades of scrap which can be melted and refined on a basic hearth. It should also be remembered that if acid furnaces were used exclusively the cost of the better grades of scrap would eventually reach pig iron prices.

In this connection, the writer heard a short time ago of an interesting process which was contemplated. It was described as a reverse-duplex, employing electric furnaces. The idea was to melt scrap and refine it on a basic lining and then transfer the molten metal to an acid-lined furnace for finishing, the assumption being that steel finished in an acid furnace is a quieter metal and more thoroughly deoxidized. Provided acid steel is superior to basic steel, the question is whether the additional cost entailed in transferring the metal and the additional power which would be consumed would be so great as to make the process impractical. As a matter of fact, there is nothing to choose between properly made steel of a given analysis, whether acid or basic. Basic steel requires more technical and careful attention, but, given that, it is as satisfactory a steel as acid steel.

Extravagant Claims Discountenanced

Another important change in the attitude of the steel founding industry toward the electric furnace today has to do with the claims for efficiency which are made by the various manufacturers. During the past two or three years, when the electric furnace was just coming into recognition, practically all builders went the limit on claims as to efficiency. Statements as to kilowatt hour-consumption figured as low as 450 kilowatt-hours per ton. It is only fair to say that the same was true in the early days of the converter, the open hearth and practically all melting equipment.

Today the steel founder recognizes that power consumption in an electric furnace is governed by a few elementary points of furnace design, including:

1.—The radiating surface of the furnace and the depth of refractory material.
2.—The number of doors and the method of closing doors.
3.—The number and size of electrodes.
4.—The speed of melting down.

The ideal electric furnace should have:

First.—A combination of minimum practical radiating surface and maximum practical depth of refractory material.

Second.—A minimum number of doors commensurate with speedy and efficient working of the furnace and doors of a type that will work easily and close tightly so as to exclude air drafts and prevent loss of heat from the furnace.

Third.—A minimum number of electrodes entering the furnace and a minimum practical size of electrodes.

Fourth.—A maximum power input commensurate with practical operation of the furnace and consequently a maximum speed of melting down.

Providing a furnace meets with these fundamental requirements, the further efficiency of the unit depends upon the electrical and mechanical correctness with which the many minor details are carried out.

It is practically impossible to make any definite comparisons as to power consumption of various types of furnaces because, as Mr. T. S. Quinn pointed out in his paper presented at the Cleveland convention in 1916, there are so many variable factors to be considered. The care taken by the operator of the furnace in killing the metal, the character of the scrap to be melted, the question of whether more than one charging of a heat is necessary to achieve the full-rated holding capacity of the furnace, these and other points all have a bearing upon the kilowatt-hour consumption.

Power Conditions Govern

The type of furnace which the steel founder can install is today dependent largely upon the local power conditions. There can be no question that the single-phase type of electric furnace is the simplest and for straight melting down work somewhat more efficient. A considerable number of single-phase electric furnaces were installed in this country during the last few years, when power companies were anxious to secure any kind of electric furnace load. Today the situation has changed, and power companies are very cautious as to the type of electric furnace equipment which they permit on their lines. Cities where the power companies formerly welcomed single-phase electric fur-

nace loads are today refusing to accept such loads. Cities like Cleveland, Toledo, Cincinnati, and practically all the big eastern cities have always refused to take on single-phase furnace loads. For this reason the steel founder is practically restricted to a choice between furnaces of the multi-phase type, or furnaces of the single-phase type operated by motor-generator set. The large additional investment which is necessary, and the larger power losses in the motor-generator set practically put the single-phase furnace so operated out of consideration. The steel founder has then for his choice furnaces of either the three or of the two-phase type. The two-phase furnace, by employing either single-phase transformers, Scott-connected, or single-phase transformers operating on an open delta, gives a balanced load over the three phases of a three-phase line.

The development of the electric process has been so rapid, and the application of the electric furnace has become so widespread, that it is difficult to surmise just where the future will lead us. There is one significant point, however, which, no doubt, has been given serious thought by steel founders and which will have an important bearing under conditions of readjustment. The writer refers to the fact that the majority of the electric furnaces for steel foundry work being installed today are being put in by manufacturing concerns who intend to employ the electric furnace either for the production of their own work exclusively, or in many cases for the production of their own work and also for taking on outside jobbing work in small quantities. This tendency has, of course, been accelerated by the fact that many concerns have had great difficulty in securing delivery of castings under the present market and have had to pay well for what they did get.

Electric Furnaces Have Arrived

We can say at this time that the electric process has definitely arrived and is going forward much further still. The steel founder who installs an electric steel furnace today knows he is buying equipment which, like any other melting equipment, is susceptible to a certain amount of trouble and difficulties, but he also knows that he is buying an equipment which, given

sufficient care and thought, will do definite things in a worth-while way. The cost of operating an electric furnace is no longer a matter of doubt, and the better quality of metal, the important feature of the electric process, is generally recognized to be due to the following factors:

First.—The fact that steel can be made more uniform in chemical content and specifications can be met more closely because conditions in the electric furnace and process are ideal for controlling the carbon, silicon, manganese, phosphorus and sulphur.

Second.—The fact that steel can be made more solid and free from blow-holes because conditions in the electric furnace and process are ideal for excluding oxygen and for producing a "dead melt" by judicious use of alloys.

Third.—The fact that the steel has a denser structure and a higher tensile strength due partly to the exclusion of oxygen and freedom from nitrogen and partly to the peculiar reaction which occurs in the electric process.

Report of the A. F. A. Committee on Gray Iron Castings

The Committee on Gray Iron Castings continued its work during the past year through several sub-committtees.

The sub-committee on Car Wheel Castings, H. W. Ufer, chairman, has prepared tentative specifications on car wheels, which are under consideration with the car wheel committee of the American Society for Testing Materials.

The sub-committee on Pipe Castings, Alex. T. Drysdale, chairman, has submitted specifications for pipe and has been authorized to consult with the pipe committee of the American Society for Testing Materials for revision.

The sub-committee on Automobile Castings, H. B. Swan, chairman, is working on the problem of suggesting specifications for this class of material.

The sub-committee on Agricultural Castings, John H. Ploehn, chairman, has made no report.

The sub-committee on Hydraulic and Steam Castings, R. S. McPherran, chairman, has made no report.

We believe that during the coming year some substantial progress can be made in the way of writing specifications.

W. P. Putnam, *Chairman*
Dr. Richard Moldenke
D. W. Sowers
J. J. Wilson

Briquetting Foundry Borings

By A. L. Stillman, New York

The melting of cast iron borings has always been a source of trouble in foundry practice. In fact a great many machine shops sell borings direct to the blast furnace, where they are highly prized as an addition to the charge on account of their cleansing qualities. Such practice is unquestionably wasteful, and the use of borings directly in the cupola with minimum loss and without impairing the quality of the product has been the object of much study. The charging of borings as such into the cupola results in heavy metal losses and in a burning out of carbon and silicon to such an extent that the product approaches low quality white iron. An improvement has been made by boxing the borings and in some cases placing them in an iron pipe and gradually lowering into the melt, the pipe melting with its contents. Great care must be exercised to prevent a break in the container in applying these methods.

In Europe application of briquetting to cast iron borings has met with a very considerable success. Here, while we have very largely adopted briquetting to the salvage of brass, bronze, aluminum and the more valuable nonferrous chips and borings, the use of the cast iron and steel briquettes is not yet widespread. A complete series of tests was run with the co-operation of the Southwark Foundry & Machine Co. and the Baldwin Locomotive Works during May of this year by Thomas Gilmore Jr., chief engineer of the General Briquetting Co., New York. The object of these tests was to show the effect of the admixture of briquetted cast iron borings upon the cupola product.

Description of Briquetting Press

In making the briquettes, the Ronay metal briquetting press was used. This is illustrated in Fig. 1. This press consists of a horizontal rotary table in which are set six molds, 5 or 6 inches in diameter. By means of a hydraulic valve gear, the

table is rotated automatically, stopping every 60 degrees of the operating period. Perhaps the best way to describe the action of this press is to outline the course of one of the six molds throughout the circuit of the table, bearing in mind the fact that the three major operations of packing, pressing and ejecting are simultaneous on three different molds.

The first operation is filling and packing. Chips drop

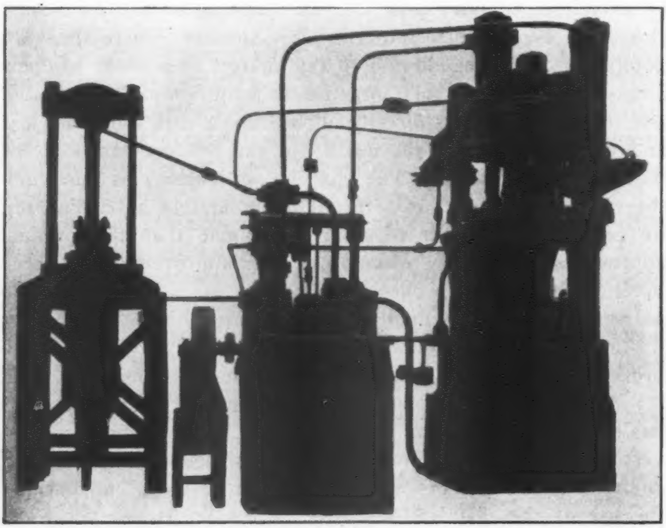


FIG. 1—RONAY METAL BRIQUETTING PRESS USED FOR TESTS

from a hopper until the mold is filled and the contents are packed by a hydraulic plunger working from above. At the end of the rest interval the table automatically rotates 60 degrees bringing the mold to an idle position where it awaits the finishing of other operations on molds before and behind it. At the conclusion of the second rest period, another 60-degree turn brings the mold under the heavy pressure piston. Here a stationary counterplunger is above while beneath the mold is a sliding plunger operated by a hydraulic piston. Slowly, to facilitate expulsion of contained air, compressive force is

admitted by means of the valve gear, and the lower plunger is forced against the mold. The counterplunger balances the pressure of the lower plunger so that complete compression is obtained on both sides. The pulsating of the pump gives a spasmodic and shaking movement to the rising of the mold, assisting to a marked degree the expulsion of the air. This expulsion of air is extremely important, as briquettes containing a quantity of atmospheric air under pressure burst under application of heat, causing considerable trouble in the furnace,

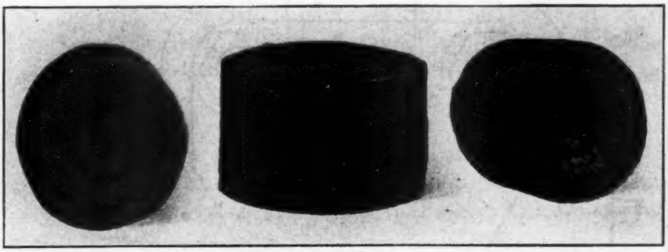


FIG. 2—TYPICAL BRIQUETTES OF METAL BORINGS FOR USE IN CUPOLAS

together with the forfeiting of all advantages claimed for briquetting.

It may be said in passing that the chief merit of this press as used, lies in the fact that the briquettes practically never explode or break in any way under the heat.

The pressure in this second operation reaches a maximum of 30,000 pounds per square inch. The pressure is held at maximum for an appreciable interval to secure a permanent set.

At the conclusion of the rest period the table is automatically rotated another 60-degree turn, and the mold is again in an idle position. Here it remains throughout the rest period as before, then another 60-degree turn carries the mold to the ejection position, where a hydraulic plunger ejects the briquette from the mold. At this point the briquette is simply removed from the receptacle under the ejector by the operator. In commercial briquetting, a conveying belt carries off the briquettes automatically. After the ejection, another 60-degree turn brings

the mold to the idle position. Thence, the period of rest again complete, it is returned to the feeding position as before.

Auxiliary Equipment

The hydraulic machinery necessary for the operation of this press to secure the pressure of 30,000 pounds per square inch,

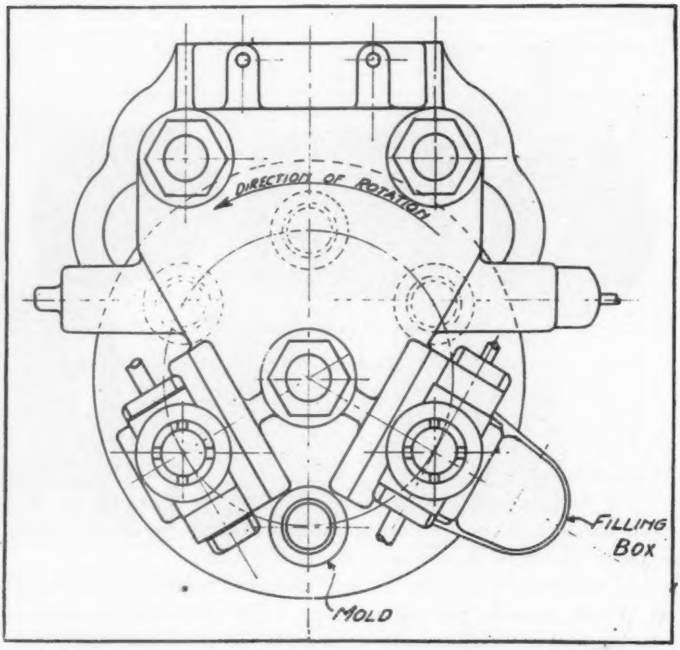


FIG. 3—PLAN OF ROTARY TABLE OF BRIQUETTING PRESS

is as follows: One 7-inch x 7-foot stroke tank accumulator; one 2¼ x 12-inch duplex double acting horizontal pump with a capacity of 40 gallons per minute under 1500 pounds working pressure, a crank shaft speed of 50 revolutions per minute and one 5½ x 11 x 28-inch intensifier together with the necessary piping and valves. The valves consist of the pressure valve for the main and packing cylinders on the press, the pressure

valve for the intensifier and ejecting cylinder, and the pressure valve for the table ram cylinder. These are controlled by means of a cam arrangement whereby the proper intervals are obtained. The table is advanced by means of rack, pinion and clutch. It is brought to a stop and in position by means of a bracket swiveled on one of the main posts which engages a stop on the table.

It is impossible, within the limits of this paper, to go into a close description of the valve action whereby the power is applied as needed upon the material in the molds.

The cast iron borings from which the briquettes were made on this run were medium cut assorted borings made at the foundry of the Baldwin Locomotive Works. The briquettes made were 5 inches in diameter and came out uniformly between 7 and 8 inches high, weighing about 28 pounds each. The density was about 80 per cent the normal density of iron. In this experiment it was desired to show that an admixture of 10 to 20 per cent of briquettes to the regular scrap and pig charge in the cupola would give a resulting metal adapted to the purposes required.

Accordingly it was arranged to make two series of tests; one of the miscellaneous mixture and the other on locomotive cylinder mixture. The regular mixture for miscellaneous casting consists of 60 per cent scrap and 40 per cent pig iron. The cast iron for locomotive cylinders (the regular mixture) is made from 50 per cent scrap, 10 per cent car wheels and 40 per cent pig iron. It was especially desired to show that the use of briquettes would justify lowering the per cent of pig iron required. Four mixtures were made on each class of material, the total weight of each charge being 3000 pounds. In the miscellaneous mixture, No. 1 consisted of 10 per cent briquettes, 60 per cent scrap and 30 per cent pig iron, the briquettes therefore taking the place of pig iron in the melt. In test No. 2, 10 per cent briquettes, 50 per cent scrap and 40 per cent pig iron were used, the briquettes taking the place of the scrap. In test No. 3, 20 per cent briquettes, 50 per cent scrap and 30 per cent pig iron were used, the proportion of briquettes being divided between the scrap and the pig iron, 10 per cent of each being substituted. In the case of the locomotive cylinder mixture four tests were also run—one of the regular mixture

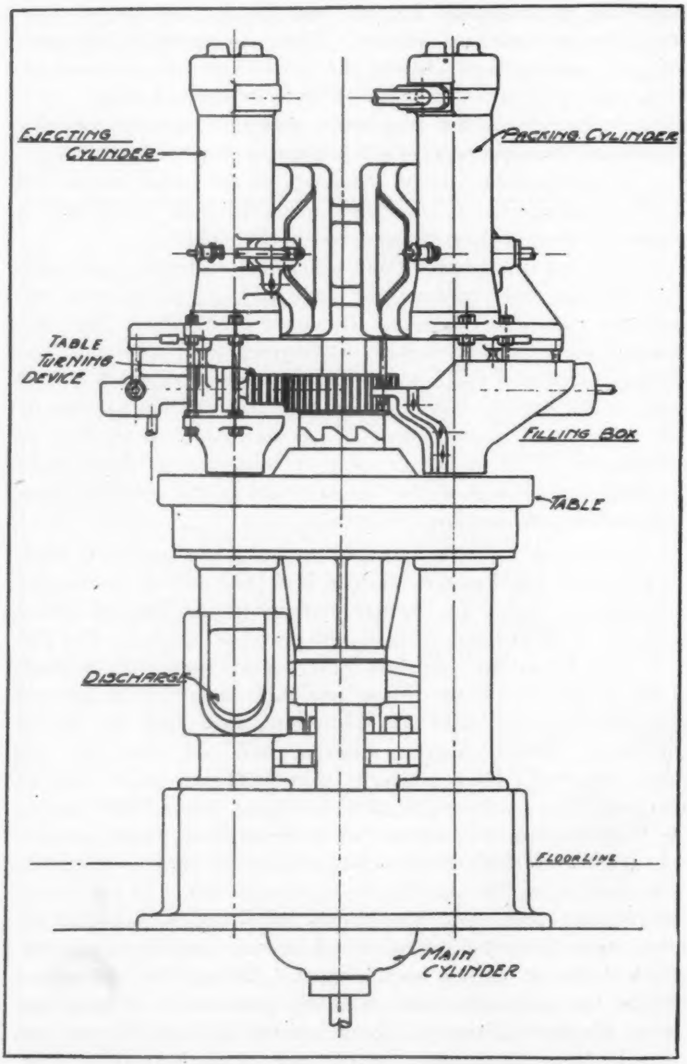


FIG. 4—ELEVATION OF BRIQUETTING PRESS

as above. Test mixture No. 1 consisted of 10 per cent briquettes, 50 per cent scrap, 10 per cent car wheels and 30 per cent pig iron, the briquettes in this case taking the place of the pig iron. Similarly test No. 2 contained 10 per cent briquettes, 40 per cent scrap, 10 per cent car wheels and 40 per cent pig iron, the briquettes taking the place of the scrap, while in test No. 3, 20 per cent briquettes were used, 40 per cent scrap, 10 per cent car wheels and 30 per cent pig iron, the briquettes taking the place of 10 per cent scrap and 10 per cent pig iron, respectively. The per cent of car wheels was the same in each mixture. The tabulation of the charges was as shown in Table I.

Charging the Briquettes

In loading the charge, the briquettes were put on top so that they would not be subject to heavy impact during the charging. The melting was entirely satisfactory and proceeded along regular routine lines. The briquettes melted evenly from the outside. Test pieces were made from each of the mixtures respectively and were subject to deflection and the transverse and tensile tests. Each test piece was analyzed for combined carbon, manganese, sulphur and silicon. The analyses are as follows:

	Combined Carbon per cent	Mang'ese per cent	Sulphur per cent	Silicon per cent
Regular Miscel. Mix..........	0.56	0.83	0.061	2.25
Miscel. Test Mix. No. 1......	0.61	0.60	0.093	2.12
Miscel. Test Mix. No. 2......	0.62	0.90	0.084	1.64
Miscel. Test Mix. No. 3......	0.69	0.62	0.087	1.86
Regular Cylinder Mixture....	0.69	0.39	0.106	1.24
Cylinder Test Mixture No. 1..	0.77	0.34	0.108	1.24
Cylinder Test Mixture No. 2..	1.04	0.38	0.103	1.19
Cylinder Test Mixture No. 3..	1.32	0.23	0.097	1.15

There is a very perceptible increase to be noted in the combined carbon. The free carbon, not shown in the analysis, is liberated in part and another part taken up in combination in the melt. This contributes better structure and stronger iron and may be considered as a benefit due solely to the use of briquettes. I do not consider the manganese determination sufficiently definite to warrant any conclusion, although there is

a diminution presumably due to oxidation. On the other hand, there is a slight increase in sulphur in the miscellaneous mixture and strangely enough a decrease in sulphur in the cylinder mixture. The increase in sulphur, something generally to be deplored, means a more finely granulated structure and in cylinder work would give good service. The decrease in silicon is marked more in the miscellaneous casting than in the cylinder iron. Unquestionably, this decrease has a tendency towards harder metals. In the test pieces, and especially in the cylinder mixture, a progressive increase in depth of chill was shown, the lowest being the regular mixture and the highest the No. 3 test piece. From the foundrymen's point of view, considering the work for which the iron was designed, the mixtures containing briquettes were as good if not better adapted to that work than the regular mixtures used.

Results of Physical Tests

The transverse tests on the test pieces made resulted as shown in table II.

In all cases, the deflection at 1000 pounds was the same and there is little difference at 2000 pounds, and though mixture, No. 3, in each case, shows a greater deflection at 3000 pounds than does the regular mixture, it is hardly enough to draw a definite conclusion. The rupture would seem to indicate that the use of briquettes had increased the resistance of the iron progressively in proportion as the briquettes were used, there being a difference of 600 pounds at rupture between the regular mixture and mixture No. 3. On the other hand, the cylinder mixture shows a decrease under the same conditions, although it should be noted that the average breakage point of the three test pieces is 3930 pounds, while that of the regular mixture was 4000 pounds—certainly not a difference of any great moment. The results of tensile tests are shown in Table III.

With the exception of miscellaneous iron test piece No. 2, which failed under comparatively light load, the result expressed in breaking strength per square inch was extremely uniform and would indicate, so far as tensile resistance is concerned in

these mixtures, that the use of briquettes has little influence one way or the other.

The conclusion is, therefore, that briquettes of cast iron have a very definite and promising future in foundry practice. It seems conclusive that they in no way injure the resulting melt and their use results in very great economy.

As is well known, there is a very large differential between the cost of light borings and heavy iron scrap. The cost of briquetting is never more than $1.50 per ton and even as low as $1.00. It can be confidently predicted that briquettes, as a part of melting mixtures, will be standard practice in the future.

Table I

MATERIALS USED IN TEST MIXTURES

Cast Iron for Miscellaneous Castings

	Briquettes		Scrap		Pig iron		Total weight of charge
	pounds	per cent	pounds	per cent	pounds	per cent	pounds
Regular Mixture.....	...	..	1800	60	1200	40	3000
Test Mixture No. 1..	300	10	1800	60	900	30	3000
Test Mixture No. 2..	300	10	1500	50	1200	40	3000
Test Mixture No. 3..	600	20	1500	50	900	30	3000

The analysis of the pig iron was as follows: Silicon, 2.6 per cent; phosphorus, 0.08 per cent; and sulphur, 0.03 per cent. The scrap was mostly foreign material; the analysis of this material can be assumed as: Silicon, 1.8 per cent; phosphorus, 0.7 per cent; and sulphur, 0.09 per cent.

Cast Iron for Locomotive Cylinders

	Briquettes		Scrap		Car wheels		Pig iron		Total weight of charge
	lbs.	per cent	lbs.	per cent	lbs.	per cent	lbs.	per cent	lbs.
Reg. Cyl. Mix..	...	..	1500	50	300	10	1200	40	3000
Test Mix. No. 1.	300	10	1500	50	300	10	900	30	3000
Test Mix. No. 2.	300	10	1200	40	300	10	1200	40	3000
Test Mix. No. 3.	600	20	1200	40	300	10	900	30	3000

Hard and dense West Virginia coke containing 0.8 to 1 per cent sulphur was used. One part of coke to 8 or 9 parts of iron was used. The inside diameter of the cupola was 54 inches and the melting capacity was about 15,000 pounds per hour.

Table II

RESULTS OF TRANSVERSE TESTS

	Diam, inch	Deflection at 1000 pounds	2000 pounds	3000 pounds	Rupture pounds
Miscel. Iron, Reg. Mix...	1.29	0.05	0.09	0.10	3000
Miscel. Iron, Test No. 1..	1.29	0.05	0.09	0.11	3400
Miscel. Iron, Test No. 2..	1.31	0.05	0.085	0.10	3550
Miscel. Iron, Test No. 3..	1.284	0.05	0.09	0.11	3600
Cyl. Iron, Reg. Mix......	1.291	0.05	0.09	0.11	4000
Cyl. Iron, Test No. 1....	1.338	0.04	0.08	0.10	4400
Cyl. Iron, Test No. 2....	1.281	0.05	0.085	0.11	3700
Cyl. Iron, Test No. 3....	1.28	0.06	0.09	0.12	3700

Table III

RESULTS OF TENSILE TESTS

	Diam. Inch	Area Sq. In.	Breaking Strength pounds	Stress per Sq. In.
Miscel. Iron, Reg. Mix....	0.786	0.485	15,100	31,140
Miscel. Iron, Test No. 1...	0.792	0.493	15,300	31,030
Miscel. Iron, Test No. 2...	0.805	0.509	12,100	23,770
Miscel. Iron, Test No. 3...	0.763	0.457	14,100	30,850
Cyl. Iron, Reg. Mix......	0.744	0.435	14,300	32,880
Cyl. Iron, Test No. 1......	0.795	0.496	18,700	37,700
Cyl. Iron, Test No. 2......	0.776	0.473	16,700	35,310
Cyl. Iron, Test No. 3......	0.778	0.472	15,600	32,840

Discussion

Dr. Richard Moldenke:—Mr. Stillman's paper is practically a continuation of the paper I wrote for the Pittsburgh convention. This present paper describes the presses that are used and also gives a series of experiments that have been made at the Baldwin Locomotive Works in Philadelphia, on the strength of the castings with given percentages of briquettes in the mixtures. Now the situation at the time

I helped to bring this process from Europe was a rather bad one because the price of borings was pretty high and pig iron and scrap were low. The process has its advantages and disadvantages and the conditions at that time made the disadvantages outweigh the advantages. Since the beginning of the war things have changed in this country. I myself helped to introduce this process into the United States. The press mentioned in the paper is the very one that was brought to America and failed at the Westinghouse Air Brake Co. Now it has succeeded. The owners have a second machine in operation also and have since ordered a third. A cast-iron chip has a very small weight as compared with a very large surface, and even when it is compressed under the enormous presses used in the briquetting process it will still retain some of its surface as against weight characteristics. The oxidation is stronger, the silicon burns out more easily, total carbon content goes low and the sulphur runs up.

Mr. S. D. Sleeth:—I think Dr. Moldenke has covered the subject pretty well. We had trouble in getting the briquettes solid. Also we found in using them that they hardened the iron by taking in sulphur and decreasing carbon, and the melting loss was high, but aside from that, we got good prices in the Pittsburgh market for our turnings and there was no economy in briquetting them. But in some places where you could not get a good price for your borings it might be more practical. The castings were hard to machine.

Dr. Richard Moldenke:—When the machine was sent over from Europe, I urged the makers to provide for small section briquettes. The nearer the section to pig iron the better, as they will not then interfere with the proper operation of the cupola. On the other hand, the European makers of the machine thought they might as well make the briquettes larger to get a good tonnage per hour. They made them 7 inches in diameter. They were so big that occasionally half a briquette would come out unmelted on dropping the bottom. We had a lot of correspondence and thousands of dollars were spent, but finally they admitted

I was right. In compressing the briquette at 30,000 pounds, you must take time, otherwise they will fall apart easily. If you let them stand 24 days the compressed air seeps out. The Europeans thought it was because of an oxidation inside. There is nothing to this idea. It is compressed air retained within, and if you will give it time to escape you can get results. The man that was sent over there found that when he kept full pressure on for about 20 seconds he got a sound briquette every time.

Note on Fine Facing Molding Sand

By C. P. KARR, Washington, D. C.

This paper is a continuation of the "Report on Molding Sands" read before the annual meeting of the American Foundrymen's association at Cleveland in September, 1916.

The growing scarcity and consequently increased cost of fine French molding sand used as a facing sand in both the ferrous and non-ferrous metal foundries stimulated the desire to find in this country a facing sand equal to the imported French sand.

To make the proper comparisons it was necessary to investigate the imported French sand and ascertain its properties as a molding sand. It was submitted to a mechanical analysis, and determinations were made of its specific gravity, moisture content, melting point, and tensile strength. In the last tests, the amount of water used in tempering the sand, the temperature at which the briquettes were molded, and the drying time were varied and noted. The method of ramming the molds and the exposure to dampness were kept as uniform as possible.

The sands studied were fine French imported molding sand; a fine grained sand from Zanesville, Ohio, furnished by L. K. Brown; a No. 000 Albany sand, furnished by J. W. Paxson Co., Philadelphia; and No. 3 North river sand furnished by Whitehead Brothers, New York. It is hoped to add the Windsor Locks fine facing sand to this group before the investigations are completed.

Increased Strength Shown

With two exceptions the Zanesville sand shows increased tensile strength as the amount of water used in the mixing is increased. As a rule the specimens were dried in an oven for 48 hours. In some of the experiments with French sand the specimens which were oven-dried for 70 to 72 hours showed

an increased tensile strength over similar specimens dried for a shorter period of time.

The important requisites of a fine facing sand are a high melting point, a fine texture, which is best expressed by the average grain size of the sand, a low moisture content, and a high tensile strength, which, in foundry parlance is expressed by the phrase—"a good bond."

The grains of a facing sand are necessarily so fine, and the mass of the quartz particle is so small in relation to its area, as compared to the corresponding quantities of a regular molding sand that the value of a facing sand depends to a considerable extent upon its tensile strength. Upon this property depends its power to bond in with the molding sand with which it is placed in contact.

Permeability Relatively Unimportant

The quartz particles of a fine facing sand are more uniform in grain size than the quartz particles in a coarser sand; furthermore, on account of the fact that the ratio of the depth of the facing to the depth of the backing is negligible, permeability and porosity are properties which are not of so much importance in a facing sand as in a general molding sand.

In the series of experiments, the No. 3 North River sand represents the average molding sand and the tests show what may be expected of it. The No. 000 Albany represents the finer grades of Albany sand and is used for facings for large castings that require a smooth finish. The sand that most closely approaches the French sand in its desirable qualities is the Zanesville sand. This sand is more uniformly fine and of smaller grain than the French sand, which has a higher melting point, less moisture content, and a greater tensile strength. The tabulated results are appended.

Tests of Transverse Strength of Molding Sands

The transverse strength is determined on a bar of sand 1 inch square and 12 inches long. The bar of sand is first air dried for 24 hours and then mixed with 7½ and 10 per cent of water by weight, respectively. The bar is molded in a bronze

mold placed on a glass plate. The mold is first filled loosely with sand, then tamped down with a small iron rammer, then filled up again and tamped once more; then it is filled over flush with sand and rammed lightly with a light wooden rammer, smoothed off and scraped level with a slicker. Then the bronze mold, being in two parts, is pulled away from the bar leaving it intact on the glass. The bar is then weighed and pushed gently at a uniform rate over the edge of the glass. As treated the bar becomes a cantilever beam, breaking by the weight of the sand pushed over the rim of the plate. The transverse strength is expressed in pounds per square inch. In the stronger sands it is possible to get two transverse tests on each bar; in the weaker sands, three such tests are possible. Three full length bars of each sand are tested for each amount of water added.

The author is indebted to W. H. Sligh for making the tensile tests and the mechanical analyses of the various sands, to C. O. Fairchild for the determination of the melting points, and to the several firms who have kindly placed samples at the disposal of the bureau.

MOLDING SAND TESTS

Sieve Analysis

Sieve mesh and size of opening—Per cent passing each sieve

	200 .074 mm .0029 inch	150 .104 mm .0041 inch	100 .147 mm .0058 inch	65 .208 mm .0082 inch	48 .295 mm .0116 inch	35 .417 mm .0164 inch	28 .589 mm .0232 inch	20 .833 mm .0328 inch	Aver. mesh fineness	Specific gravity	Moisture content %	Melt'g point Cent.
Zanesville, O.	55.3	83.8	92.9	96.5	98.2	99.8	100.0	.....	185	2.68	3.3	1580
Imported French ...	55.8	74.8	88.8	96.1	98.8	99.5	99.8	100.0	170	2.63	1.0	1650
No. 000 Albany	31.0	49.4	75.2	94.2	98.1	99.0	99.6	100.0	86	2.64	0.6	1570
No. 3 No. River	5.6	6.6	13.3	23.4	39.5	66.2	89.0	98.6	56	2.62	0.8	1550
Windsor Locks	85.24	97.3	98.0	99.4	99.6	99.8	....	100.0	from 450 to 500	2.7	0.64	1465

Note.—Material was dried out in oven at 105 degrees Cent. All determinations made on material after drying. Average grain size according to W. S. Tyler screen scale.

TENSILE TESTS OF FINE MOLDING SANDS

Zanesville, Ohio, Sand

Water, per cent	Temp. Cent.	Hours	No. of bri-quettes	Lbs. per sq. in. average	Remarks
12.0	21.0	48	2	7.38	Dried in oven 48 hours at 105 degrees Cent. Sand pressed in molds 6 times on opposite sides. In damp closet, 24 hours. In air, 24 hours.
7.0	25.5	48	2	3.13	
10.0	20.0	48	2	2.75	
6.0	23.0	48	3	2.75	
16.0	23.5	48	2	2.00	
6.0	19.0	48	2	3.00	Rammed on one side only with thumb.
7.0	25.0	46	3	4.00	Rammed on both sides with thumb.
10.0	24.0	48	3	7.00	After 48 hours in damp closet.
21.5	24.0	48	2	13.00	Rammed both sides with thumb.

Imported French Sand

Water, per cent	Temp. Cent.	Hours	No. of bri-quettes	Lbs. per sq. in. average	Remarks
7.5	20.5	48	9	9.50	In damp closet 24 hours. In air 24 hours.
7.5	21.0	48	9	12.70	Sand and water mixed 3 minutes.
7.5	21.5	72	9	11.70	Molds pressed 6 times by hand on two opposite sides.
7.5	21.0	70	8	14.70	Sand dried out in oven 60 hours at 105 degrees Cent. Sieved through 14 mesh.

No. 000 Albany Sand.

Water, per cent	Temp. Cent.	Hours	No. of bri-quettes	Lbs. per sq. in. average	Remarks
10.0	23.5	48	3	6.50	Molds pressed 6 times by hand on two opposite sides.
10.0	23.0	48	6	6.66	
7.0	22.0	48	2	3.00	

No. 3 North River Sand

Water, per cent	Temp. Cent.	Hours	No. of bri-quettes	Lbs. per sq. in. average	Remarks
7.5	23.0	48	6	4.70	Molds pressed 6 times by hand on two opposite sides.
7.5	20.5	48	6	3.12	
7.5	22.0	48	8	4.34	

SUMMARIES OF TESTS

Sand	Per cent water	Transverse strength, lbs. per sq. in. 1st bar	2nd bar	3rd bar	Average
No. 3 North River	7½	2.11	1.90	2.00	2.00
	10	2.26	2.20	2.23	2.24
No. 000 Albany	7½	2.32	2.42	2.28	2.84
	10	3.43	2.67	2.44	2.84
Windsor Locks	7½	3.49	2.62	2.61	2.90
	10	2.78	2.62	2.78	2.72
Zanesville	7½	2.20	2.06	2.13	2.13
	10	1.98	2.58	2.50	2.35
Imported French	7½	4.59	5.16	3.68	4.47
	10	4.93	2.78	5.64	4.45

It is to be noted that the North River No. 3, the No. 000 Albany, and the Zanesville sands reach their maximum strength with 10 per cent water, whilst the Windsor Locks and the Imported reach their maximum strength with 7½ per cent water, in the case of the tests as carried out. It is evident from a comparison of the results that none of the American sands approach the French sand in transverse strength.

The Seasoning of Gray Iron Castings

By L. M. SHERWIN, Providence, R. I.

The term seasoning is a very broad one and numerous definitions can be found covering various methods of procedure, but the one which has the most bearing on this subject is as Webster gives it, namely, "the maturing or the changing from the crude to the more perfect condition; to mature; to grow fit for use." This is what actually happens to gray iron castings when they are subjected to any process tending towards their improvement. The necessity for seasoning is due largely to internal strains and existing stresses arising usually from the design of the casting, or from some unusual condition such as heat and cold being applied to any one particular location on a casting and not to the other sections.

There are several different methods of seasoning castings in vogue at the present time, and it would be difficult indeed to determine without actual experimenting with the various processes just which method would be the more valuable and which one could be recommended the most highly. Individual requirements would be the governing factor in determining the method, and would therefore prevent making a general or definite assertion.

Some of the methods being used are as follows:

1.—Castings remaining in one place and position for an indefinite period, and in some cases exposing them to weather conditions, before they are finish-machined.

2.—Castings having been rough-turned or planed, and then subjected to a heat of several hundred degrees, say as high as 400 degrees, Fahr., for a definite period of time.

3.—Castings heated from 150 degrees, Fahr., to 300 degrees, Fahr., before having the scale removed.

4.—Castings heated and re-heated several times at 400 degrees, Fahr.

It is generally recognized that there is some benefit to be derived from some sort of seasoning. It has been found that the castings after receiving this treatment will have a greater tendency towards holding their shape more permanently than those that have not received any treatment, and, as far as is known at the present time about straightedges, surface plates and other castings of a similar nature; the second method is preferable and can be recommended.

Effect of Design on Shrinkage

Much has been written about shrinkage, internal strains, external stresses and contraction, and all of these factors have a decided relation to the seasoning process. The shrinkage, both internally and externally, usually is the result of poor designing, but there are many instances where the mixture of the gray iron is entirely at fault, causing these unusual conditions. With a casting so designed that there are several, or even one heavy and one light section, the heaviest portion will naturally be the last to become solid, which indicates that the lighter section on cooling drew the molten metal to that part and in so doing left void places in the heavy sections. The reductions in the various dimensions of a casting, after reaching the solidified state, is known as the contraction. Sometimes the internal shrink is referred to as the *spongy shrink,* and the external shrink as the *sucking in shrink.* The former in many cases is caused by the carbon in the mixture being too high, while the latter is due to too low carbon in the mixture. The above conditions will effect the strains and stresses, and, as these are the governing factors regarding seasoning, every known precaution that is practicable should be observed in order that castings to be seasoned will be sound and be of good texture, regardless of the method which is to be used later in seasoning. The casting undergoes expansion and contraction during the process of cooling from the molten state to the solidified condition and after reaching this state the mobility of the molecules will allow for seasoning.

Many interesting experiences and facts have been brought out during the past few years in connection with seasoning and several experiments carried through which have proven

more or less successful. At the present time tests and experiments are being conducted with surface plates and straightedges to determine the best and most economical method of handling gray iron castings for these purposes.

Several years ago an elaborate system, consisting of a large box containing coils of steam pipes, was installed. The castings were placed in the box and live steam passed over the castings through the pipes; thus raising the temperature in the box to the desired degree. This system was discarded as being too expensive for the results obtained. The value of this method has always been a debatable question.

Attempts to Equalize Stresses in Castings

Various efforts have been made to equalize the strains and stresses. Some of these have been the designing of a surface plate with two parallel faces and a uniform distribution of metal throughout. This particular casting has been in daily use for several years and seems to be giving entire satisfaction. The casting was first rough-planed and then heated. Also there have been castings such as sliding tables designed with several medium and light sections, as well as other castings with all the sections of relatively the same proportions and weight. Experience has proved the uniformly designed table to be less changeable. It is probable that by heating the former castings to some definite degree for several hours their tendency to warp would be materially lessened.

Instances where manufacturers have claimed that a certain straightedge had changed its shape during the day have been investigated, and it was found that the room temperatures were affecting the marking (the marking is shown by rubbing the prepared surface against a master plate). The temperature of the room in such cases was about 60 degrees Fahr. Upon raising the temperature to 70 degrees the trouble was entirely eliminated.

It has also been found that the temperature will materially affect the marking of all surface plates and straightedges, and the most satisfactory temperature for working conditions at which the marking and scraping is done is about 70 degrees Fahr. It is almost impossible at the present time, unless under

ideal conditions regarding room temperatures, to scrape and mark these castings in one continuous period. Some castings are started and worked on for one-half hour between the hours of 7:00 a. m. and 7:30 a. m., then they are laid aside for two hours and at 9:30 a. m. the scraping is again started and finished. The change under these conditions is no greater than 0.001 inch in a length of 6 feet. In the winter the changes referred to are more perceptible than in the summer, and the long narrow castings show a more noticeable change between the temperature of 60 degrees Fahr. and 70 degrees Fahr. than from 70 degrees Fahr. to 80 degrees Fahr. A difference of 10 degrees makes a change in the marking of approximately 0.001 inch. If a straightedge is marked and scraped at 70 degrees Fahr., then marked again at 85 degrees Fahr., it is very seldom that any change can be detected. If, on the other hand, the castings are marked and scraped at 70 degrees Fahr., to say 60 degrees Fahr., a noticeable change takes place. Of course, where there are heavy and light sections and corresponding strains and stresses, the light sections are more easily affected by the rise and fall of the temperature.

Castings Sensitive to Slight Temperature Variations

The placing of the bare hand on the center of a straightedge 4 feet long in less than half a minute changes the marking. Consequently, all surface plates and straightedges are fitted with wooden handles to be used by the workman to prevent this change from heat conditions. The sunlight coming through a window and striking such castings quickly changes them.

When working on straightedges, one man has three straightedges, and, if on surface plates, he has two. The trouble is usually encountered in the machining and scraping, and it is a very expensive proposition to re-finish these castings after they have been once finished. Therefore, every precaution is taken to make the casting as nearly correct as possible. The best results can be obtained by seasoning.

Every surface plate and straightedge is first rough-planed and then subjected to a temperature varying from 350 degrees Fahr. to 550 degrees Fahr., depending entirely on the size, shape and class of the castings. Some castings require 350 degrees, others 400 degrees Fahr., while still others may require

500 degrees Fahr. After heat treating, the castings are finish-machined and then scraped.

It is wrong to assume that after a casting has been seasoned that it will be immune from any changes. Excessive heat and cold will always affect the castings, but after the cause has been removed the castings return to their original shape unless the heat or cold has been so intense that the castings have become warped. In such an event, re-machining is necessary.

Long narrow plates give far more trouble in machining and scraping than square castings. Very little difficulty is experienced with narrow castings of short lengths.

Castings which have not been heat treated and are left for a long period of time in the yard exposed to the weather, are found to be seasoned to an extent about equal to that which the castings receive from heat treatment. If unlimited time could be given to castings which need fine finishing and scraping, they could undoubtedly be seasoned as well without heat as with it, but the condition of manufacturing at the present time would make this plan prohibitive.

Are High Temperatures Desirable?

It has been reasoned that if heating to from 300 degrees Fahr. to 500 degrees Fahr. proves beneficial, why would not a higher temperature be more effective? On the assumption that this theory is correct, we have at the present time various castings undergoing this treatment. The castings have been carried through the various processes up to scraping and marking, and it is to be regretted that more time was not available for the completion of these experiments. To date the results have been fairly satisfactory, but they have not reached the stage where they could be tabulated with any degree of certainty as to their correctness. To date the relative merits of the plates heated to 400 and 1100 degrees Fahr. are about equal. Before proceeding with these experiments it was absolutely necessary to determine what temperature would be a safe maximum to adopt for the treatment of the castings when considering the wearing qualities, shape, etc. The transformation range for cast iron of this grade is between 1250 and 1375 degrees Fahr. This means that when

heated above the latter temperature the combined carbon, structurally termed pearlite, is changed slowly into its elements, namely, iron and carbon. Later at a higher temperature the graphite increases the size of the previously formed graphite.

Carefully conducted experiments with this iron to obtain heating and cooling curves resulted in establishing the arresting point on cooling at 1330 degrees Fahr. A long period of heating at a temperature below this range, namely, 1100 degrees Fahr., should not affect the microstructure of any component. To verify these premises was one of the objects of the heat treating experiments.

Twenty castings were used in these experiments and were cast at approximately the same time in the heat and under the same conditions, such as rapidity of pouring and temperature of the metal. The castings were all removed from the sand at about the same time and an equal chance given for cooling. All were rough-planed and some of them subjected to various heats, while others did not undergo the heat treatment.

The castings used in the experiments were four straightedges, 1⅞ x 36 inches; six straightedges, 2 x 48 inches; four surface plates, 24 x 48 inches; and six surface plates, 6 x 26 inches. A set of two test bars were cast with the same mixture and at the same time as were each of the four 24 x 48-inch surface plates, and marked *1A, 1A', 2A, 2A', 3A, 3A', 4A* and *4A'*. The bars *1A, 2A, 3A* and *4A* were tested as cast. Bars *1A', 2A'* and *3A'* were tested after being heated as follows:

1A' heated to 400 degrees Fahr. for a duration of 24 hours.

2A' heated to 1100 degrees Fahr. for a duration of 24 hours.

3A' heated to 1100 degrees Fahr. on three different occasions and cooled in each case.

The bar *4A'* was tested as cast. In each case the bars *A* and *A'* were cast at the same time and in the same mold.

Another test bar, *B*, cast of the same quality iron, was then heated to 1800 degrees Fahr., but the micrograph proves the method to be undesirable.

It was desired to ascertain, if possible, the differences in the chemical composition and physical condition between the bars as they were cast and after being heated to various temperatures. The four 1⅞ x 36-inch straightedges were treated as follows:

1.—Heated to 400 degrees Fahr. for a duration of 24 hours.
2.—Heated to 400 degrees Fahr. for a duration of 72 hours.
3.—Heated to 400 degrees Fahr. for a duration of 168 hours.
4.—No heat.

The 2 x 48-inch straightedges were treated as follows:

1.—Heated to 350 degrees Fahr. for a duration of 24 hours.
2.—Heated to 350 degrees Fahr. for a duration of 48 hours.
3.—Heated to 350 degrees Fahr. for a duration of 72 hours.
4.—Heated to 1100 degrees Fahr. for a duration of 24 hours.
5.—Heated to 1100 degrees Fahr. three different times and cooled in each case.
6.—No heat.

The 6 x 26-inch surface plates were treated as follows:

1.—Heated to 400 degrees Fahr. for a duration of 24 hours.
2.—Heated to 1100 degrees Fahr. for a duration of 24 hours.
3.—Heated to 1100 degrees Fahr. on three different occasions and cooled in each case.
4.—Heated and re-heated several times at 400 degrees Fahr.
5.—Placed in yard for an indefinite length of time.
6.—No heat.

The 24 x 48-inch surface plates were treated as follows:

1.—Heated to 400 degrees Fahr. for a duration of 24 hours.
2.—Heated to 1100 degrees Fahr. for a duration of 24 hours.
3.—Heated to 1100 degrees Fahr. on three different occasions and cooled in each case.
4.—No heat.

The chemical analyses of the test bars and the results of physical tests are shown in the table on page 517.

In my estimation the subject of seasoning gray iron castings has never received the amount of attention it justly deserves, and, as this work covers individual requirements, the subject has been approached from experiences within our field of endeavor and which have come under our observation.

Questions Still Unsatisfactorily Answered

The following questions have been asked and up to the present time the writer feels that the answers are still a matter of personal opinion and still remain in doubt. Therefore, the

questions cannot be answered fully and correctly. The questions are:

1.—What are the actual relations of seasoning to internal and external stresses and strains?

2.—Will the chemical composition have a direct bearing on results for castings to be seasoned?

3.—What is the quickest and most accurate way of determining whether the castings are stressed; and, if such is the case, what is the most effective way of realizing the value of these stresses?

4.—What is the best method of seasoning to determine which process would be of the greatest value and at the same time the most economical?

To arrive at any definite conclusions regarding the above questions, it will be necessary to experiment to a much greater extent than has been done up to the present time. It is to be hoped that such experiments, which are based on sufficient data to be worthy of attention, will be published. Failures as well as successes should be recorded, as each failure will then help towards ultimate success.

CHEMICAL COMPOSITION OF TEST BARS

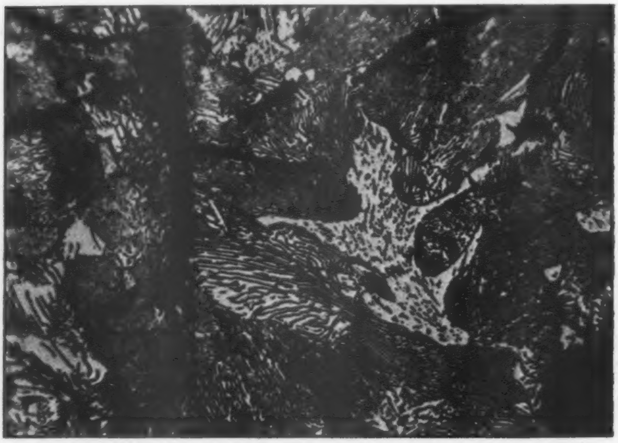
	1A	*1A'*	*2A*	*2A'*	*3A*	*3A'*	*4A*	*4A'*
Silicon	1.86	1.87	1.75	1.83	1.91	1.93	1.95	1.97
Sulphur	0.116	0.115	0.118	0.119	0.080	0.075	0.081	0.078
Manganese	0.56	0.52	0.54	0.51	0.51	0.53	0.51	0.53
Phosphorus	0.49	0.42	0.44	0.41	0.49	0.45	0.48	0.47
Combined Carbon	0.73	0.69	0.71	0.65	0.79	0.67	0.68	0.64
Graphitic Carbon	2.47	2.47	2.47	2.51	2.57	2.61	2.77	2.75

TENSILE TESTS		SCLEROSCOPE TEST		BRINELL TESTS	
Bar	Pounds per Square Inch	Bar	Number	Bar	Number
1A	37,200	*1A*	36	*1A*	207
2A	37,000	*2A*	34	*2A*	207
3A	36,300	*3A*	33	*3A*	187
4A	34,300	*4A*	36	*4A*	183
1A'	36,900	*1A'*	35	*1A'*	192
2A'	35,100	*2A'*	35	*2A'*	196
3A'	36,000	*3A'*	33	*3A'*	187
4A'	35,400	*4A'*	37	*4A'*	196

The micrographs shown on the succeeding pages were prepared by Saunders & Franklin, Providence, R. I.

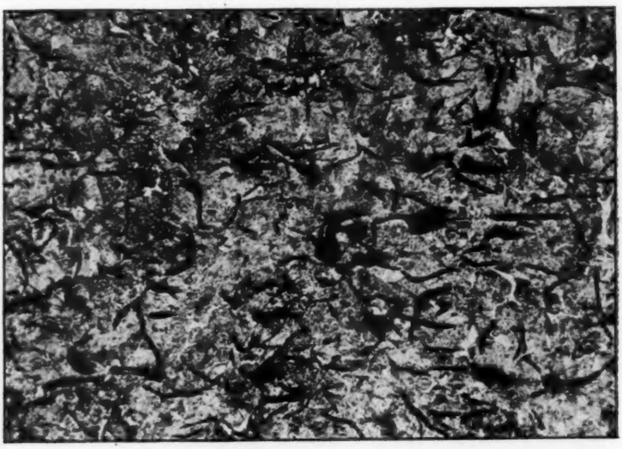
MICROGRAPH OF TEST BAR 2 A'

Heated at 1100 Degrees Fahr. for 24 Hours. Microstructure Unchanged
C-854, Etched. 100 X



TEST BAR 2 A'

Heated at 1100 Degrees Fahr. for 24 Hours. Microstructure Unchanged.
C-854, Etched. 500 X



MICROGRAPH OF TEST BAR 2 A

Microstructure as Cast.

C-845, Etched. 100 X

TEST BAR 2 A

Microstructure as Cast

C-845, Etched. 500 X

MICROGRAPH OF TEST BAR *3A*

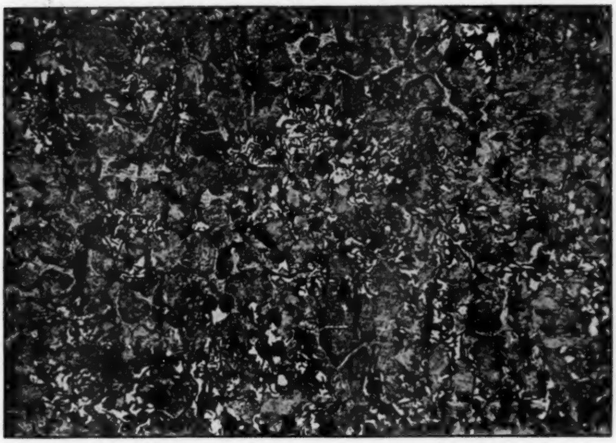
Microstructure as Cast

C-846, Etched 100 X

TEST BAR *3A*

Microstructure as Cast

C-846, Etched 500 X



MICROGRAPH OF TEST BAR 4A
Microstructure as Cast
C-847, Etched 100 X

TEST BAR 4A
Microstructure as Cast
C-847, Etched 500 X

MICROGRAPH OF TEST BAR 1A
Microstructure as Cast
C-844, Etched 100 X

TEST BAR 1A
Microstructure as Cast
C-844, Etched 500 X

MICROGRAPH OF TEST BAR *3 A'*

Heated at 1100 Degrees Fahr. for a Period of One Hour, Three Different Times. Microstructure Unchanged

C-855, Etched 100 X

TEST BAR *3 A'*

Heated at 1100 Degrees Fahr. for a Period of One Hour, Three Different Times. Microstructure Unchanged

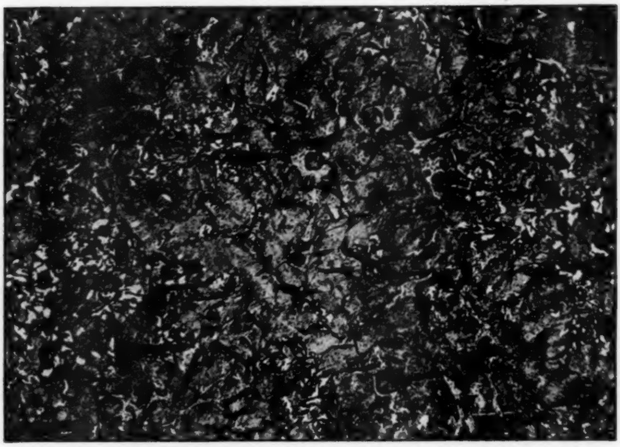
C-855, Etched 500 X

MICROGRAPH OF TEST BAR *1 A'*

Heated at 400 Degrees Fahr. for 24 Hours. Microstructure Unchanged
C-856, Etched 100 X

TEST BAR *1 A'*

Heated at 400 Degrees Fahr. for 24 Hours. Microstructure Unchanged
C-856, Etched 500 X



MICROGRAPH OF TEST BAR 4 A'

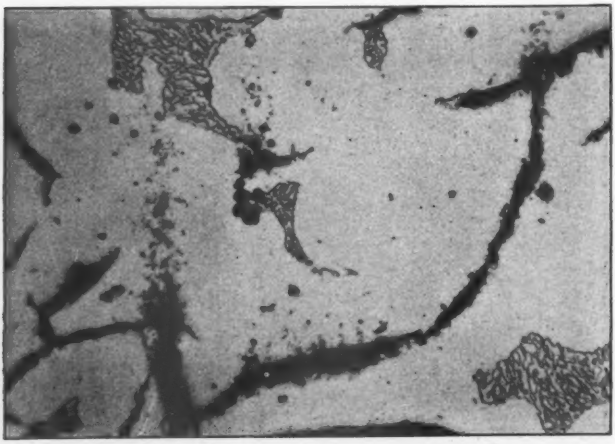
C-857, Etched — Microstructure as Cast — 100 X

TEST BAR 4 A'

C-857, Etched — Microstructure as Cast — 500 X

MICROGRAPH OF TEST BAR *B*

Heated at 1800 Degrees Fahr. for 24 hours. Pearlite Completely Decomposed. Graphite Flakes Larger. Phosphide Structure Altered
C-851, Etched 100 X



TEST BAR *B*

Heated at 1800 Degrees Fahr. for 24 Hours. Pearlite Completely Decomposed. Graphite Flakes Larger. Phosphide Structure Altered
C-851, Etched 500 X

Factors in the Economical Production of Small Cores in Large Quantities

By R. E. Kennedy, Urbana, Ill.

Modern manufacturing, even before the pressure brought to bear on it by the present war, was demanding that all processes and equipment which tend toward more efficient production, should be given careful consideration. Methods used in radically different lines of work can often be studied and then perhaps be applied to new conditions and produce good results. Manufacturers must keep pace with the progress of manufacturing in their own fields or else soon find that their methods are of little value in meeting competition.

A manager, to get the most out of his plant, cannot rely entirely on past experience for the highest development of his work. The broad principles of management are the same in any line of manufacturing, and when these are known and each plant is studied and the methods analyzed in the light of these principles, good results are bound to result if the manager has the ability to grasp the full meaning of the principles and apply them to his plant. The management of the core room of a foundry, although not generally considered in the same class as many other plant departments, has to deal with the same principles which govern all other divisions of a manufacturing plant.

All factors of manufacturing must be governed by ultimate costs and when applied to the core room, may be classified as the workers, the materials, and the equipment and its arrangement. Managers of core rooms on studying their departments from these three viewpoints will bring to light many things which they will want to improve. If they do not so study their work, they will continue in their old way of performing their part of the manufacturing processes and will not keep up with the demands for greater and better production.

Standardization, recognized by manufacturers as an essential feature of their business, brings good results to the core room. The use of unstandardized materials, methods and equipment in the shape of varying core sands, binders, working of core boxes and use of miscellaneous plates, leads to constant trouble and loss of time.

The use of the special handling equipment like the lifting truck and its attendant special and standard platforms, which is now so common in general manufacturing, is just beginning to make its appearance in the core room, where it has many opportunities to effect economy.

Core rooms in which the production consists of large numbers of small cores lend themselves ideally to the application of most of the methods employed in plants where stores used directly or indirectly for war purposes are made.

Core Room Labor—A Vital Foundry Problem

The question of the worker is as vital to the core room foreman as in any department of a plant and the same care has to be exercised in obtaining and training this class of foundry help as in other lines of work. The writer will not go deeply into this subject, but wishes to call attention to the fact that since men are being called on to perform military service and are being used in the heavier work of manufacturing, that the necessity for using women and girls will be felt as soon by the core room foreman as by the head of any other shop department. While some foundrymen already employ women in their core rooms, there are many others who could do so profitably on nearly all the operations in small core work. Women should not be asked to work under some of the dirty conditions prevalent in quite a few of these core rooms. If all foundrymen would only realize that they can produce better results with more contented labor, by having clean, well lighted, well ventilated surroundings, they would be in a position to use to advantage women in their core rooms without doing an injustice to this class of workers.

A number of core room foremen have tried out girls and women as coremakers and have become disgusted, while others who went about the proposition in a different way have found

that girls, when properly instructed, turn out better small cores than boys or men employed in similar work. It has been the experience of those who have given women a fair trial that where the work requires deftness, a quick hand and a quicker eye, girls are more proficient.

Objection is also made to the use of women by some foremen because they say they have to have boys to carry

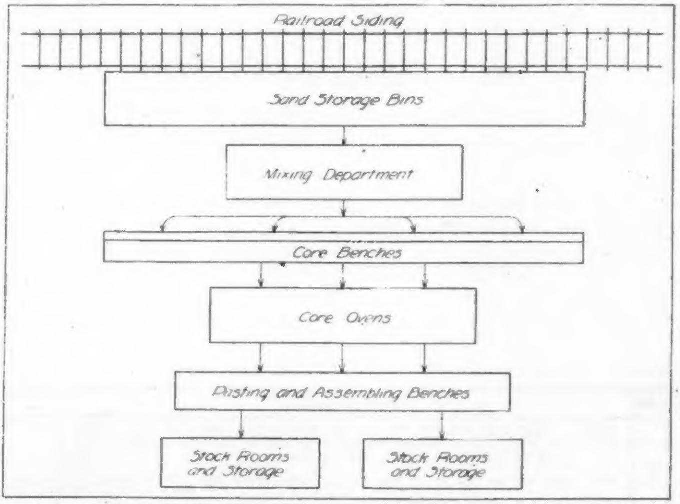


FIG. 1—CHART OF THE USUAL PROGRESS OF THE FLOW OF MATERIALS IN A CORE DEPARTMENT

Each step should be considered to establish the work in the most efficient manner.

the cores to the ovens and remove them from the ovens. This specialization of the work of the different operations is being found by the larger manufacturers to be the real solution of their problems of large output. Thus, instead of finding this division of labor a hindrance, they find it of great value. The coremaker who has to leave his bench to take his cores to the oven, get his plates and sand, loses more time in getting settled down to his work again than if the cores were carried away by cheap special labor and the sand, plates and dryers were also brought as his needs demanded.

FORM 102

INSTRUCTION CARD

SHOP LABORATORIES

FOUNDRY DEPARTMENT

PART CORE SAND MIXTURE No 3

ARTICLE PATT. NO.

FLOOR BENCH MACHINE STATION 4

STANDARD FLASK NO.
SPECIAL FLASK NO
CORE BOX NO. CORE PLATE NO
SAND MIXTURE NO
WIRE. SIZE RODS. SIZE
NO LOOSE PCS NO. CORES

TOOL KIT NO.
RAMMER
FACING MXT. NO.
TACKLE No 2 Shovel
No A Wheelbarrow
No 8-21" Riddle
Quart Measure

ITEM	OPERATION ROUTINE	STANDARD TIME
	NOTE. CARD MADE OUT FOR TWO (2) #4 WHEELBARROW LOADS OF CORE SAND MIXTURE. IF A LARGER QUANTITY IS NEEDED USE QUANTITIES OF MATERIALS IN THIS SAME PROPORTION.	
1.	FROM SAND BIN NO. 1 OBTAIN 300 LBS OF SAND. DUMP INTO MIXING BOX........	0.05
2.	FROM SAND BIN. NO. 4 OBTAIN 200 LBS OF SAND. DUMP INTO MIXING BOX.....	0.08
3.	RUN SAND THROUGH RIDDLING MACHINE WITH 1/8" RIDDLE....................	0.03
4.	ADD THREE (3) QUARTS OF CORE OIL (GRADE #2) AND 2 GALLONS OF WATER....	0.02
5.	RUN SAND THROUGH MIXING MACHINE.......................................	0.06
6.	DUMP FROM MIXING MACHINE AND SHOVEL INTO MIXTURE BIN #3...............	0.04
	TOTAL STANDARD TIME	0.28

FIG. 2—INSTRUCTION CARD

Effort should be put forth to see that the sand and binders purchased run true to a standard quality. Then definite routines can be followed and exact amounts of materials used in making up the core sands. This will insure uniform results in cores, both while green and in the dry state. Written instruction cards can then be made out for the men doing the mixing to follow.

Younger boys will also have to be used in larger proportions as the older men leave for other lines of work, and while this will tend toward greater specialization by confining them to a limited class of work, yet in fairness to them, they should be given a chance to learn as much of the varied character of the work as possible. As the discussion in this association in recent years has shown, the specialization of men in high production work in molding and coremaking is creating a dearth of competent foremen for the foundry.

Laying Out for Straight-Line Flow

The location of the core room depends on several factors which are not always taken into consideration when building a foundry. These factors are:

1. The size of cores. Large cores demand that the location of the core room be fairly near point of use of cores in the molds. Small coremaking can be centralized for the transporting of cores to the molder is less of a burden.
2. The number of pounds of cores used per molder has a bearing upon the distance between the core room and the point of molding.
3. Strength of individual cores. Where cores are necessarily rather weak the longer hauling and repeated handling leads to high loss.
4. Methods of handling. Use of adequate transportation equipment over free gangways or overhead conveyors permits of greater hauling distances with less breakage.

Centralization of coremaking can be taken advantage ot when the cores are small and the transportation facilities are good. Confining all the coremaking to one place reduces labor and floor space.

As in other lines of manufacturing the core room has the same degree of adaptability to being laid out for the straight-line flow of material through the department from raw material to the finished product.

As usually seen, the average core room has not been laid out with an eye towards the easy and natural flow of sand from sand storage to batch mixer and through the operations in the core room to the foundry. This process is very definite and much advantage can be gained by closely studying the problem and working out the scheme which will best suit conditions

This is especially necessary when the space left for the core room work is limited and operators work close together.

All who are in any way familiar with core work have seen many examples of the evil resulting from narrow gangways and work going back and forth over the same path. Those who are designing a new layout have a much easier proposition

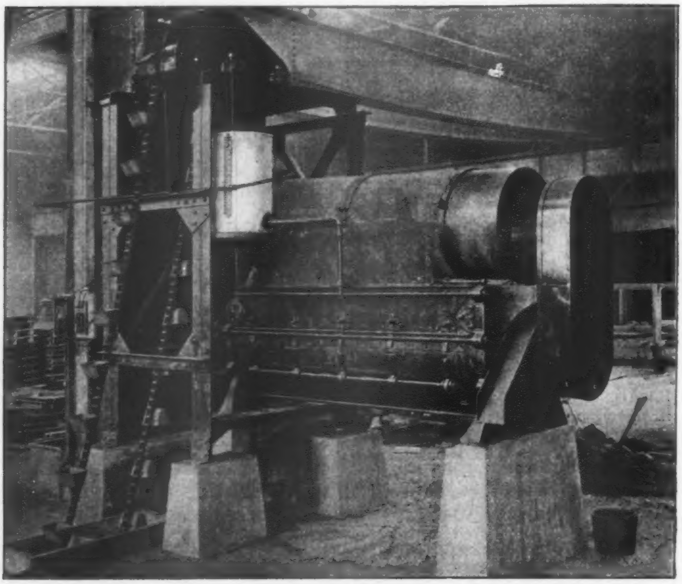


FIG. 3—SAND MIXER INSTALLATION FOR ECONOMICAL AND ACCURATE MIXING OF LARGE VOLUMES OF CORE AND FACING SANDS

in this respect than those who have to take over an old department and straighten out the kinks in the flow. As indicated in Fig. 1, all work should progress through the following steps, in the order named: Sand storage; batch mixer; storage for batches of various mixes; core bench; oven; pasting, blackening and assembling; re-drying, if necessary; and stock storage.

Methods of Storing Sand

The writer has worked in some foundries where the coremakers often had to take a bucket or wheelbarrow and go

several hundred feet to the sand sheds, get the sand needed and laboriously wheel or carry it to the core room. Even if it is possible to have railway facilities direct to the core room, the sand to be used for cores should be housed in bins or sheds located near the core room. The most logical way to bring the sand there, is to have it shoveled direct from the cars into convenient bins. If not so located and changes cannot be made, it will have to be handled by cars on an industrial track, by horse and wagon, or by the old familiar wheelbarrow. The core room then should be taken into consideration when laying out the foundry and given its place close to the railroad siding.

A mistake made by one company, operating a rather large Ohio plant, occurred because when the foundry was organized, the work was of such a nature that the number of cores made was small and the amount of sand used was correspondingly a small factor. Without considering that later they might wish to make work requiring larger number of cores, they located the core room on the opposite side of the foundry from the railway facilities where the iron and coke were being handled. What little sand was used was handled without difficulty in wheelbarrows through the molding floor gangways. Later, when the work was changed to take in a large amount of gas engine parts, the core room was enlarged, but the sand still had to be brought across the foundry in the same old way. Thus a large amount of labor was used in the hauling, and the handling of sand conflicted with the legitimate traffic on foundry gangways. This condition was so intolerable that the core room had to be moved to the opposite side of the foundry near the railroad siding.

Some foundrymen, realizing the necessity for having sand mixes made as standard as possible, have installed equipment for drying the sand. Coremaking, like good cooking, has to be exact and if conditions vary from time to time trouble is experienced in working the core sand in the boxes, due to sticking or being too dry, or too weak or too hard when baked. Therefore, a sand of absolute uniformity in moisture content is necessary to begin with, and when damp sand is used directly in making mixtures, this absolute uniformity is not obtained.

FIG. 4.—CORNER OF A CORE ROOM SHOWING ROLL-OVER MACHINES, SIDE STANDS AND SAND BENCHES, WHERE CYLINDER AND CRANK CASE CORES ARE BEING MADE.

The limited gangway for transporting sand to the benches, along which all materials and cores must proceed, leads to confusion and loss of time due to conflicting flow of work. The equipment is good but the layout poor.

One large foundry has the sand room so constructed that heating coils run through covered concrete passageways under the sand, drying it out. Cheaper installations, but which are more laborious to manipulate, consist of small sand heating stoves.

Dry sand occupies less space than wet sand and it has been ascertained that if 10 per cent of water is added to clean lake or silica sand, there is an increase of about 40 per cent in volume. This should be taken into consideration when buying and making up core sand mixtures. When adding binder to sand of varying moisture content, the strength of the resulting cores will be different and the number of cores obtained from mixing up a wheelbarrow load of dry sand will be greater than the number obtained when starting with a wheelbarrow of damp sand. Therefore, it is rather important to start with sand always of the same moisture content and as dry as it is practicable to obtain it. With dry sand as a basis, then binder and water in exact amounts can be added with every assurance that core sands of the same physical qualities will be turned out, day after day.

Mixing Rooms

The mixing room of the average foundry, if there is one, varies to a great extent in size and in location as related to the straight-line flow. It should be located as directly between the sand storage and core room as possible, with easy passageway for trucks. A mistake often witnessed is to place the mixing equipment either in some out-of-the-way bin or directly in the core room, where it is in the way of the coremakers. Conditions of a similar nature would not be tolerated in many of the other manufacturing departments. Neatness and order are today universally recognized as being essential to obtaining the highest possible output.

As to the equipment needed in a mixing room, it will of necessity differ principally as the amounts of sand and binder which are daily mixed. It is essential that standard measuring instruments either in the shape of cups, boxes, buckets, or barrows and riddling and mixing machines be used. The employment of uncertain and varying sized measures leads not

only to the use of excessive amounts of binders, but also to the occasional lack of the full amount needed. One defect is about as bad as the other. Where the usual trade grade of unskilled labor is used and indefinite instruction given, this variation is the rule. A cheap workman can very soon run the cost of mixing up very much beyond what would more than pay for the employment of a careful man and provide

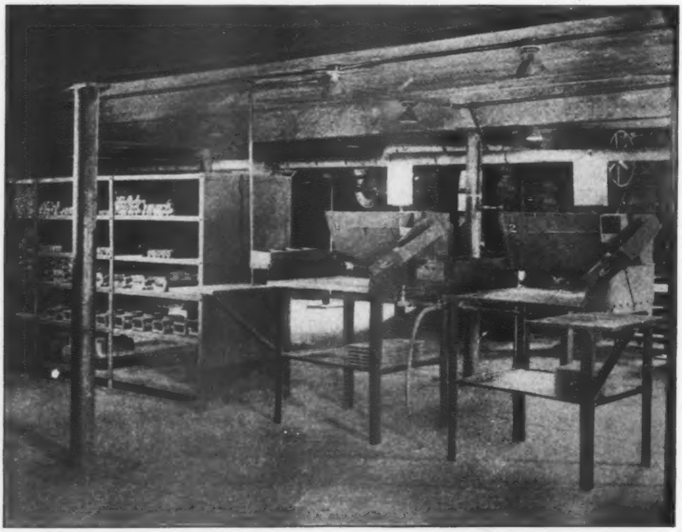


FIG. 5—SOME CORE BENCHES OF A CORE ROOM TURNING OUT SMALL CORES

The benches are so arranged that the sand can be kept back in hoppers, tools have their special places and provision is made for taking care of the supply of wires and plates.

him with means for exact measurements. The high cost of cheap mixing is occasioned by losses in handling poor cores, and losses of castings, due to the same cause. This loss is hard to trace to its source, for it occurs throughout all the operations of assembling and molding.

Combined with the use of these exact measurements should go instruction cards, containing the necessary information to

obtain these exact results, even when different men do the mixing. A card somewhat similar to other instruction cards which the writer has previously explained in papers previously presented before this association, is shown in Fig. 2. Verbal directions are easily misinterpreted and lead to many unfortunate circumstances, and, because of this fact some of the leading manufacturers have adopted as a slogan: "Don't say it, write it," which certainly is productive of good results.

This careful handling of materials leads to the possible success of one core room, while lack of it might lead to the failure of another, for the materials can be bought by one firm as cheaply as the other and the buying of the same equipment is as possible for one plant as any other. This then, puts it up to good management to introduce and make effective the methods which go to make one core room turn out a cheaper and better product than another.

Investigation into the possibilities of using cheaper binders and sand often leads to large savings, as is shown in one plant where core oil and lake sand had been used in the production of transmission case cores. The investigation brought to light the fact that a mixture of glutrin, lake sand and gangway sand could produce cores of the desired physical qualities at a saving of over 50 per cent of the former price per ton of sand mixed.

The number of cores per day from the coremakers is influenced a good deal by the character of the binder, for if it tends to stick to the box the maker cannot turn out as many as where a free working material is used. This sticking to the box is due, in many cases, to too great a percentage of binder and the trouble often can be eliminated by reducing the proportion of binder. This merely indicates one place for the core room foreman to investigate and find out what would be the best standard mixture to use.

Accurate records should be kept of the costs per ton of mixing the different core sands and binder combinations and when this data has been observed for a while the importance of studying for cheaper combinations will be realized. Many core room foremen do not know what the cost per ton of their different mixtures runs, and not knowing, are not impressed

with the actual saving which can be affected by use of cheaper sands and binders. When the costs of these different mixtures are not known, very often an expensive sand is used where a less expensive one would produce as good results. Weekly summaries of the cost per ton in labor and materials used in

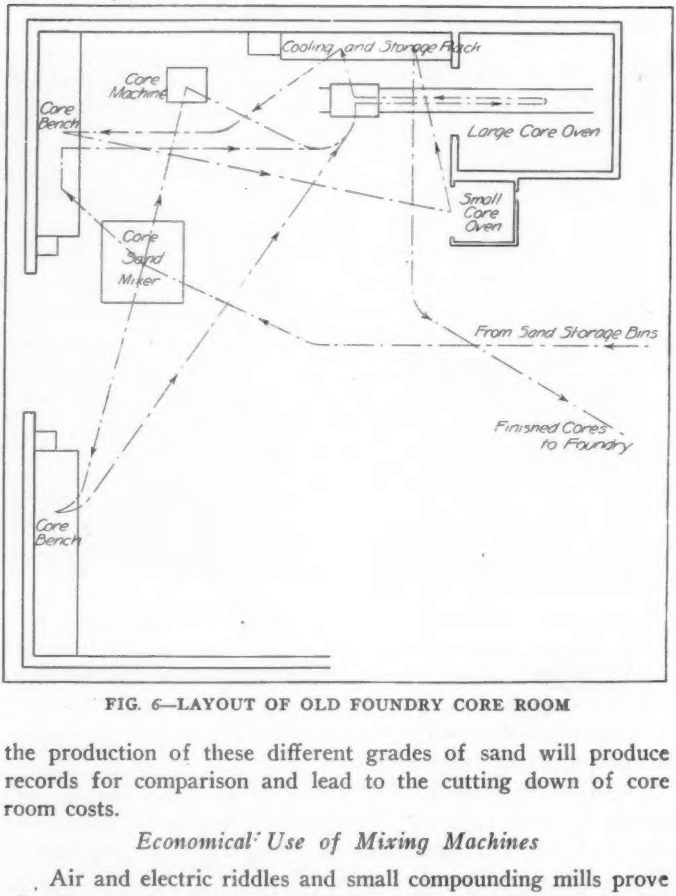


FIG. 6—LAYOUT OF OLD FOUNDRY CORE ROOM

the production of these different grades of sand will produce records for comparison and lead to the cutting down of core room costs.

Economical Use of Mixing Machines

Air and electric riddles and small compounding mills prove of value to the core room having even a small output, for the increased quality of the sand mixtures go far towards

cheaper materials and labor costs. By the use of a compounding mill one foundry was able to reduce its costs as shown in Table I and others have been able to get even better improvements over their old hand methods. The use of the compounding mill affected a saving of $0.85 per ton. Hand mixing will not distribute the binder as thoroughly through the sand as mixing machines; hence more binder has to be used to produce as strong a core by hand mixing as by machinery. Table I gives the results of using a compounding mill where it was desired to use some gangway sand in the mixture instead of all new sand.

Table I

COMPARATIVE CORE SAND MIXTURE COSTS WHEN USING COMPOUNDING MILL TO FACILITATE ADDITION OF GANGWAY SAND AND WHEN NOT USING MILL

Cost When Not Using Mill

40 per cent or 800 pounds of new molding sand at $1.20 per ton	$0.48
40 per cent or 800 pounds new sharp sand at $0.60 per ton	0.24
20 per cent or 400 pounds of old core or gangway sand 1 to 40 per cent or 50 pounds compound at $30.00 per ton	0.75
Total	$1.47

Cost When Using Mill

20 per cent or 400 pounds of new molding sand at $1.20 per ton	0.24
80 per cent or 1600 pounds of old core sand 1 to 80 per cent or 25 pounds of compound at $30.00 per ton	0.38
Total	$0.62

More extensive sand mixing plants are a necessity in the larger plants, handling many tons of sand mixture a day. Fig. 3 is taken from a photograph of a machine installation for mixing quantities of sand mixtures, where the sand is elevated, screened, water added and the mixture milled to a thoroughly uniform mass. These larger installations make a very uniform

sand mixture and the chances for variation are not as great as when smaller lots are prepared by hand. Other machines for use in the mixing room were very thoroughly discussed by E. A. Coleman in a paper presented before this association at a former meeting.

Having been mixed, the core sand is either taken directly to the core room or shoveled into bins which are temporary storage for the different grades of sand. Even in this part of the process of coremaking economies can be practiced if

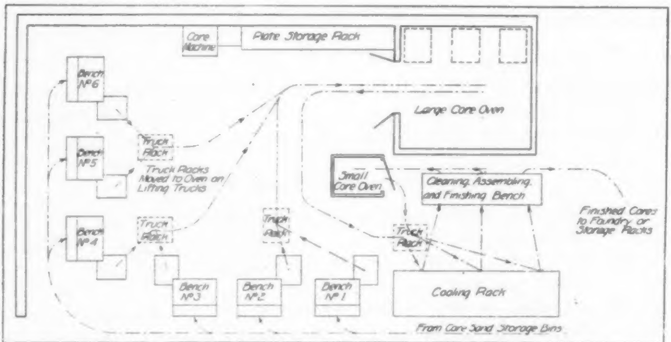


FIG. 7—LAYOUT OF NEW FOUNDRY CORE ROOM

This plan shows the steps taken to rearrange this core room to give the work a better routing. The crossing and interfering of the different work was eliminated by erecting new benches and changing the location of equipment.

thought is given to the character of the work. The bins holding the stores of mixed sand can be either conveniently or poorly constructed. One automobile casting foundry in Detroit had this stock sand thrown into bins with sides about 4½ feet high. It was very hard for the laborers to scoop this sand out either by shovel or bucket and almost impossible to clean the bin thoroughly without climbing into it and working in a cramped position. If such bins are used they should have sliding or lifting doors at the bottom, where the sand can be shoveled directly from the floor, or where possible, have the bins left open at the front.

Inefficient handling of raw material and product increase the cost of production. In the smaller plants it is a paying

proposition to handle the core sand from stock bins to mixer and core benches in wheelbarrows, for while extensive equipment in the shape of monorail carriers or rail trucks might reduce the immediate costs of handling, the expense of installation and overhead charges would more than make up for saving of direct handling costs. Nevertheless, even in small plants much can be done to systematize the delivery of core sand to the benches and do away with the necessity for the skilled workers to leave their benches in order to get their sand and do the mixing.

Crowded gangways, littered with core plates, riddles, boards and other trash go far towards making for inefficient delivery of materials. Orderliness is one of the first laws to be obeyed when high production is to be obtained. Fig. 4. illustrates a very common condition where unbaked cores, sand, plates and like material, have to travel over the same narrow gangway. The arrangement of core benches will also facilitate delivery of sand. Rows of benches ranged back to back with sufficient space for a gangway between them will allow the free passage of laborers with their wheelbarrows of sand, rods, etc., to pass without disturbing the coremakers or the cores setting on stands by the core benches. Benches with the hopper arrangement, as shown in Fig. 5, permit of a larger volume of sand being left on the bench at one time, yet without its being in the way of the worker or without having him disturbed when it is being delivered to his bench.

The charts shown in Figs. 6 and 7 show how the core room at the University of Illinois was rearranged for the better handling of materials and permitting the flow of work to progress in a systematic manner. Floor space in this case was limited and the highest ideal of straight-line flow could not be reached, but the large amount of crossing and recrossing of the paths of materials was eliminated. Core sand came from the mixer to the benches into hoppers from the back. Rods, wire and plates were also delivered to the benches by using this same gangway. This prevented much traffic from interfering with the removal of cores from the benches to the ovens. The coremakers placed their finished plates of cores on elevating truck racks, similar to the kind shown in Fig. 8. This type of truck

furnishes the means for the continual use of large truck ovens, where, when using rack trucks on stationary tracks, the oven cannot be used while the cores are being loaded into the rack and when they are being removed.

The continuous use of the ovens is a very important factor where trucks are the means for holding the cores in the oven. Where ovens have to stand idle while their truck racks

FIG. 8—ELEVATING TRUCK FOR HANDLING CORES FROM THE CORE MAKER TO THE OVENS AND THEN TO THE ASSEMBLY RACKS

Where cores are not of the extreme delicate type and are rather heavy this is proving of great value in cutting down the handling costs.

are being loaded and unloaded, just twice as much oven equipment as is required is being used.

When using steel racks in connection with these elevating trucks as many racks as can be utilized are on hand and then some are placed at the core benches and are being loaded, while yet another set can be in the oven with baking cores, with a third set with baked cores being unloaded at the assembly benches.

Where these racks can be placed back of the coremaker's bench they will produce best results, for then all the coremaker has to do is to turn around with his finished plate of cores, place them on the rack and then begin a new plate. When the rack is filled it can be removed to the oven for baking and an empty rack set in its place. This will eliminate the many trips to the ovens of the coremaker and the subsequent hunting for an empty oven shelf. In a foundry studied by the writer, the time wasted by the coremakers when taking each plate to the oven amounted to more than an average of two minutes per plate. This two minutes loss on each plate could have been reduced to a six-minute loss on 40 plates by using the portable rack.

The use of the elevating truck requires that the core room floor be in good condition, as the spoilage of delicate green cores may be considerable. Special layouts with rack cars between rows of core benches are very successfully used in some of the larger core rooms, but the system is not as flexible as the elevating truck system.

The use of the drawer type oven and rail truck type will still be the most efficient in some cases, but the management should seriously consider all methods, because additional labor and extra oven equipment should be eliminated if possible. These types must be studied to determine which method will give the most continual use of the ovens, the least amount of handling and the greatest production with the least floor space and smallest number of men.

To insure oven work of the highest degree of uniformity, ovens must be so constructed that their temperature can be maintained at a constant point. This means they must be well insulated and as free from uncontrolled air as possible.

To be sure that this constant temperature is maintained, recording thermometers should be installed to enable the oven tenders and management to know the temperature at which the oven is being kept. The thermostat used in connection with the oven flues or dampers will assist in the obtaining of an even degree of heat by providing mechanical means of damper control. Mechanical regulation, when working properly, will

always insure greater accuracy of baking than when the regulation is left to the judgment of laborers of the class prevalent around a foundry core room. While in some cases, attempts at mechanical control have been a failure, it is not to be denied that the best control will only be obtained when some such means are employed.

When running a standard mixture, it is a comparatively easy matter to find the temperature at which the cores can be baked quickest without burning the outside before the core has been thoroughly baked inside. Knowing this temperature, the ovens can always be kept worked to their highest degree of output. This is especially necessary when large quantities of cores have to be handled; for when the cores require too long a time to bake, it will mean extra oven equipment. The usual reason for failure in thus controlling the temperature is not due to the general method, but to faulty mechanical installation and poor instruction or knowledge on the part of the management. In one large core room it was found that the best results from a continuous oven system for certain cores was obtained when a temperature of 525 degrees Fahr. was maintained. For the ovens used for baking cylinder barrel cores a temperature of 500 degrees Fahr. maintained for 2½ hours gave the best results. A radiator foundry running about 35 tons of core sand a day found out when using recording thermometer control, that 380 degrees Fahr. for the first hour followed by two hours of steady heat, then three hours of slow cooling, gave the best results. The varying of the temperature was obtained by using forced draft.

Finishing and Assembling Cores

Where large numbers of cores are being made the work of smoothing, pasting, blackening and assembling cores can best be divided into separate operations so that special workers each have one or two operations to perform.

Well arranged benches are a necessity where the workers can have the cores brought to them, placed conveniently near and have stools to sit on, for on this class of small work there is no necessity for the assemblers to stand.

Fig. 9 shows a small, well arranged bench developed at the University of Illinois foundry for the workers pasting, blackening and assembling small cores. The cores from the oven are set in racks just back of these workers and to get their supply

FIG. 9—DESIGN OF A PASTING, DIPPING AND ASSEMBLY BENCH WHICH FACILITATES THE WORK OF PREPARING CORES FOR THE MOLDS

As the cores are finished they are placed on the racks at the back of the bench and are removed either to the oven for re-drying or to the storage rack for finished cores. The paste and blacking pots are of large size and are set into the bench, being located for convenience in pasting and blackening cores.

of cores they merely turn around for a plate of unworked cores. Pots holding paste and black wash are set into the bench, as shown, being located for the convenience of the worker and out of his way. When the cores are finished they are set on plates in the rack at the back of the bench. From here they are carried away by another worker who tends to the

re-drying oven. The finished assembled cores are taken direct to the core storage or the foundry.

If the benches are so arranged that successive operations can be performed by the workers sitting next to each other or across the bench from each other, the cores can be passed directly from man to man, eliminating the necessity for storing in trays and carrying or hauling to the next operation. This progressive finishing of cores is followed by several of the larger automobile foundry core room organizations.

The cores having been finished and assembled, they can best be stored in trays or boxes or on boats, where they can be left until wanted in the foundry and then carried in these same trays direct to the molder's floor, where they are wanted.

A large loss of cores occurs in many foundries because the cores are taken to the foundry on poorly constructed trays or platforms, left in the way, and if not used, they remain there to be broken by placing boards and flasks on them. This occurs in practically every foundry, for it seems almost impossible to make the molders realize that cores in the foundry represent money.

Order and Stores Control

The following description of the method of core routing and core storage used by the Mueller Mfg. Co., a large manufacturer of brass plumbing goods, will show how they have attempted and very successfully executed a plan for the control of the making of cores in the right quantity and storing them until ready for use. Hampered by a small core room, formerly a part of the foundry which, like Topsy, "just grew", as increased production was called for, they have made especial effort to produce large quantities of small cores of the very best quality. To get this quantity meant specialization of labor, careful routing of work, and well planned storage where the numerous kinds of cores could be found when needed.

Girls are used as coremakers because they have been found to be more adept at this small core work than boys or men. The writer was pleasantly surprised at the intelligent class of girls employed as compared to the class employed in several other plants. This has been made possible by the management endeavoring to maintain clean surroundings.

Factory orders made out in duplicate, Fig. 11, go to the man in charge of the core-box storage, who then gets the desired box from its rack and places it with the order on a rack accessi-

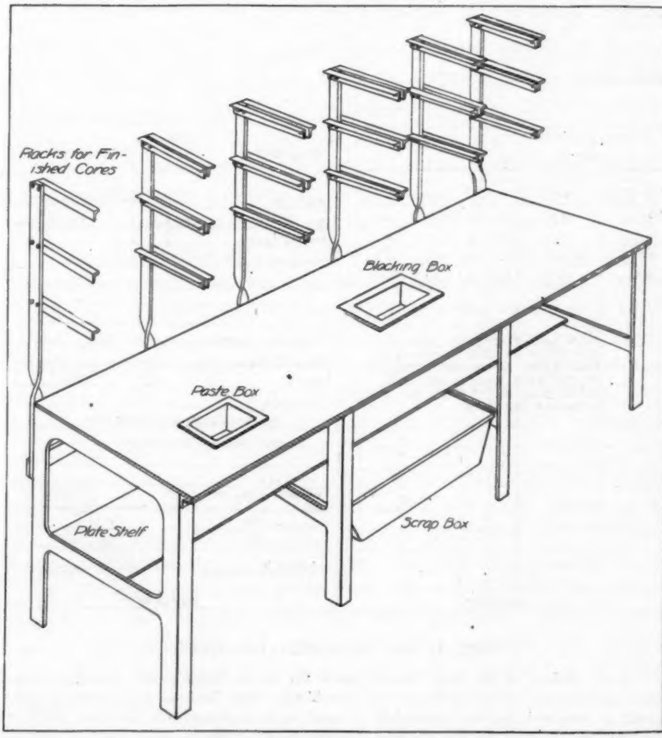


FIG. 10—LAYOUT OF A PASTING AND ASSEMBLY BENCH FOR SMALL CORES SHOWN IN FIG. 9.

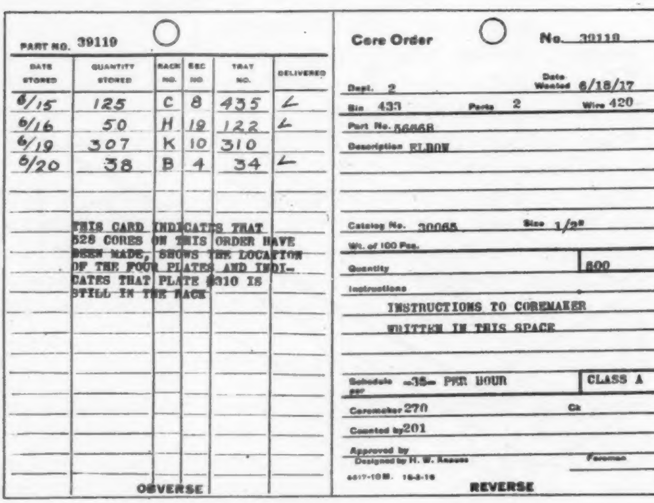
In designing this bench provision was made to enable the worker to have materials and plates located in the most convenient position possible.

ble to core room foreman. Rush orders and the corresponding boxes are immediately sent to the core room foreman in his office.

Each core has an estimated rate per hour, divided into three classes, *A*, *B* and *C*, according to their intricacy, the more

intricate being classed at *A*, less intricate as *B*, etc. The coremakers are rated according to their skill, as *A*, *B* or *C* class, and are paid a corresponding rate per hour, which they get without question, no matter how much they turn out.

If, as shown on the sample card, Fig. 11, the job is scheduled *Class A*, at 35 cents per hour, or 315 for nine hours work,



PART NO. 39119

DATE STORED	QUANTITY STORED	RACK NO.	SEC NO.	TRAY NO.	DELIVERED
6/15	125	C	8	435	✓
6/16	50	H	19	122	✓
6/19	307	K	10	310	
6/20	38	B	4	34	✓

THIS CARD INDICATES THAT 528 CORES ON THIS ORDER HAVE BEEN MADE, SHOWS THE LOCATION OF THE FOUR PLATES AND INDICATES THAT PLATE #310 IS STILL IN THE RACK

OBVERSE

Core Order No. 39119

Dept. 2 Date Wanted 6/18/17

Bin 433 Parts 2 Wire 420

Part No. 56668

Description ELBOW

Catalog No. 30065 Size 1/2"

Wt. of 100 Pcs.

Quantity 600

Instructions

INSTRUCTIONS TO COREMAKER

WRITTEN IN THIS SPACE

Schedule per -35- PER HOUR CLASS A

Coremaker 270 Ck

Counted by 201

Approved by Foreman

Designed by H. W. Knauss

4417-10M. 10-3-16

REVERSE

FIG. 11—ORDER FORM, OBVERSE

Exact orders to the core room insure the cores being ready for the molder when the foundry is scheduled to start molding. The back of the duplicate order which is retained by the coremaker is used as a memorandum to keep track of the number of cores he has made, while the back of the original copy is used by the clerk as a final record.

and the coremaker at the end of the day has produced a total of 350 or 35 above the schedule, she is paid 11 cents extra. This rate of 11 cents is paid for the scheduled number of cores per hour which are turned out in excess of the standard for *Class A*. If the cores are rated in *Class B*, the coremaker is paid 10 cents for each scheduled hour's work in excess of the standard and for cores in *Class C*, 9 cents is paid.

With the schedule rates per hour and information obtained from his assistant, the foreman at the start of work in the morning and afternoon, knows what work can be made each day, and then, from his orders, he lays out work in advance for the coremakers. The core boxes to be worked are marked with the coremaker's number and sent to a station supervised by a workman whose duty it is to get ready the wires and dryers needed. These are collected together and when the coremaker is ready to start on the new work, she proceeds to a card rack, obtains her duplicate of the work order, goes to the bench where the jobs have been laid out, obtains her box and wires, while the dryers are carried to her bench.

As she finishes plate after plate of these cores, she enters the number made on the back of her core order, Fig. 11, which gives her information, telling her when the order is finished. Each plate has placed on it an iron tag with the part number corresponding to that on the work order. The green cores are carried to the ovens by a boy whose duty it is to do this work. The ovens are charged by a man who regulates the baking and removes the cores to cooling racks. From the cooling racks they are taken to the benches where girls clean and smooth them up with graphite. The finished cores are next taken to the inspecting and checking rack. At this point the inspector notes on the back of the original order the date, the number in the tray, the rack and section number, when it is to be stored until taken to the foundry, and the tray number. The iron tag which has followed this plate of cores through the different operations is removed at this point and a paper tag is placed with the cores.

When the entire number of cores have been finished for the order, this core-order card is placed in a rack where the laborer whose duty it is to take the cores to the molders can have access to it. This man then knows where to obtain the needed cores, and as he removes them to the molding benches, checks off on his work-order card the number of the plate delivered, Fig. 11.

This system provides for having the needed cores on hand when wanted and in a known location. It also provides against dispute between the foundry and core room as to cores made

and delivered, supplies the information for the payment of bonus to the workers, and checks losses during the progress of cores from the makers to the foundry. Altogether it makes a most excellent, controlled method of having the work flow through the sequence of necessary operations from receipt of order to delivery to foundry.

Each person has his or her specified duty and becomes a specialist in that work. The summary of the flow of work is as follows:

1.—Order received at box vault.
2.—Order and box delivered to foreman.
3.—Day's work scheduled by foreman.
4.—Wire and dryer man prepares boxes of wires and dryers.
5.—Coremaker has sand brought to bench and receives box and dryers.
6.—Green cores taken by laborer to oven.
7.—Oven-tender bakes and removes cores to cooling rack.
8.—Laborer supplies girls who clean and blacken cores.
9.—Finished cores inspected and counted.
10.—Finished cores stored in racks of numbered sections.
11.—Cores removed to foundry from storage rack by special laborer as they are needed by molder.

Some very interesting points were observed in this plant besides the control of output. A special paste is used on the wires, which, while holding the wires in place, yet allows them to be removed from the casting clean. When they are not bent in being removed from the casting, they are ready for use again.

A special wire-cutting and forming machine is operated by one man, who furnished not only all the intricately bent wires for this works, but also for the Canadian plant. This machine automatically cuts and binds the wires which are used in the large number of valves, tees, faucets and other castings produced. Dies for the different shaped wires are very easily slipped into place, reducing the cost of cutting and bending to a minimum.

By the use of special sand mixtures many complicated cores are made without the use of dryers, as the mixture gives an extremely strong green core and yet cleans out of the casting with a minimum of expense. At the same time, these cores

are accurate as to size, for the type of work demands that they be so. Most of the boxes used are cut out of solid blocks of steel, giving the cores an accuracy which cannot be obtained from wooden or cast metal boxes. This method of cutting of boxes from steel makes an initially high box cost, yet the results justify this expense.

This careful control of the core output is in direct contrast to one other large automobile plant visited by the writer, where all orders were transmitted from office to foreman by word of mouth, and the foreman in turn gave his men verbal orders. The cores, when removed from the ovens, were placed around the shop in gangways on bottom boards, under benches and some on unmarked racks. Many orders were duplicated and cores were often lost by the time the molder was ready for them and others had to be made up. Others were broken because they were left in passageways, where wheelbarrows and trucks would often overturn the board on which they rested. The work of pasting, trimming and blacking the cores was scattered all around this foundry, resulting in much confusion in handling the work.

Such conditions as these do not pay, yet they can be seen in a large number of foundries. It behooves each foreman and manager to make his department a subject for analytical criticism and then do such constructive work as will keep the shop on a production basis. Find the best arrangement of equipment, put in all the labor-saving equipment which will actually reduce costs, if run properly, get the labor specialized to perform its work efficiently, and get those sand mixtures which will give the best results at the cheapest cost.

High Sulphur in Soft Gray Iron

By T. MAULAND, Chicago

Sulphur is considered cast iron's worst enemy, and many of the troubles of the foundry are laid to it whenever it happens to be high. Authorities say that sulphur combines carbon, increases hardness, shrinkage and chill; reduces strength; causes dirty iron, blow holes and shrinkage cracks; and makes iron congeal quickly. Generally this is true, but my experience has been that sulphur within certain limits increases strength in soft iron. For agricultural or similar classes of castings, specifications have called for a maximum sulphur of 0.08 or 0.09 per cent. The American Society for Testing Materials, I understand, is considering increasing this limit to 0.10 per cent.

In castings of this class, sulphur is generally used as an indication of the hardness. I have noticed, however, that castings with a higher sulphur, up to 0.12 per cent, will sometimes be good, strong and soft, while at other times, with the other elements the same, the castings will be hard with sulphur less than 0.09 per cent. It has been my experience that when using a mixture of, say, 55 per cent pig, 35 per cent home scrap and 10 per cent No. 1 cast scrap, and it became desirable on account of economy to substitute 0.12 to 0.15 per cent sulphur off-grade pig iron for the No. 1 cast scrap, I could use a mixture of 45 per cent pig iron, 35 per cent home scrap and 20 per cent off-grade pig. In other words, I would use 20 per cent off-grade pig in place of 10 per cent No. 1 cast scrap, although the average sulphur analysis of the scrap would be better than the off-grade pig. The analysis of the castings from the off-grade pig mixture would be the same, excepting it would show a higher sulphur. But the iron would be just as good and just as soft as the lower sulphur iron made from the scrap mixture.

A Bad Reputation

In steel, sulphur has had the same bad reputation that it has in the foundry. Bessemer steel specifications generally call for 0.08 per cent or less, and open-hearth specifications for 0.05

per cent or less, as the maximum sulphur limit. Dr. J. S. Unger of the United States Steel Corporation has made some extensive tests with high sulphur in open-hearth steel. These tests which were made with varying sulphur contents from 0.03 to 0.25 per cent, showed that good steel could be made with the higher sulphur. High-sulphur steel was made into rivets, chain, sheets, wire, tubes, pipes, forgings, wire rope, rails, etc. These tests showed that high-sulphur steel could be made with mechanical and working properties equal to that of low-sulphur steel.

Dr. J. E. Stead, the eminent English metallurgist, in a paper before the British Iron and Steel Institute, cites experiments with steel containing from 0.10 to 0.50 per cent sulphur with as good, or superior mechanical properties, as steel of lower sulphur. The following extracts are taken from his paper:

"It was proved long ago that manganese counteracted the effect of sulphur, but books have been written in which sulphur was condemned, and engineers and their experts read those books and copied them, so that even to this day steel rails, etc., of exceptional quality are rejected because the sulphur exceeds arbitrary limits, even when all mechanical tests proved that material is perfect. Steel high in sulphur resembles wrought iron and is more or less fibrous. It is a fact that steel called free-cutting fibrous steel is used today and the peculiar properties referred to are due to the deliberate introduction of sulphur into the steel. Such material contains about 0.15 per cent sulphur. Sulphur, then, may be regarded as a friend when it is used intelligently and is not invariably the enemy it is represented to be."

Some High-Sulphur Iron Soft

Within the last few months I have run into some rather extraordinary cases of high sulphur iron showing up very soft. The casting used as a test piece was a small gray iron box or bushing 2½ inches long with a ¾-inch core. The lighter portion, including the upper end, is 3/16-inch thick. The heavier portion is ¼-inch thick. The ¾-inch cored hole is reamed to a 0.890-inch hole on a gang drill. This machining is done with a feed of 4¼ inches per minute. This casting is one that is very apt to cause trouble in machining on account

of a hard upper edge in the lighter section. Ordinarily it is not safe to run this iron over 0.10 per cent in sulphur, and this casting has given trouble with sulphur as low as 0.08 per cent. In the cases just mentioned where the iron was satisfactorily soft the analyses were as follows:

Lot No.	Sulphur Per cent	Silicon Per cent	Manganese Per cent	Phosphorus Per cent	Total Carbon Per cent
1.......	0.156	2.11	0.44	0.70	3.39
2.......	0.143	2.12	0.44	0.70	3.47
3.......	0.145	1.93	0.46	0.40	...
4.......	0.170	2.09	0.44	0.40	...

The casting, the small box previously referred to, machined soft from all of the four lots.

The high sulphur in lots Nos. 1 and 2 was obtained accidentally. I had already tested the castings for softness, and was very much surprised that analysis showed such high sulphur. The high sulphur in lots Nos. 3 and 4 was obtained by using high-sulphur pig and adding sulphur to the molten metal.

Not So Bad As Painted

The cases of good iron with high sulphur and many cases of poor iron of practically the same analysis but lower sulphur, lead me to believe that sulphur in itself is not nearly so bad as it has been painted. Where sulphur is blamed for poor iron, I do not say that this iron would not have been better had it been lower in sulphur, but I believe that in most cases iron higher in sulphur could be made that would give satisfactory castings.

At this time I will not try to explain why some high sulphur iron makes very good castings, but I am inclined to believe that oxygen, as described in papers written by J. E. Johnson Jr., one of which was read before this association several years ago, has much to do with it. The oxygen in the four lots cited above was very low, but I have not had the opportunity to do enough work along this line to draw definite conclusions.

I intend to make some more experiments with even higher sulphur but time will not permit the results to be included in this paper. All sulphur determinations mentioned have been checked by at least one other laboratory besides our own

Oxyacetylene Welding and Cutting

By Stuart Plumley, Boston

In considering the subject of oxyacetylene welding at prior conventions of the American Foundrymen's association, attention has been centered largely upon the various classes of work which have been accomplished with the process, and in generally describing the equipment and gases used.

The process has now been employed so many years that practically everyone has a fair idea of it, and generally understands the equipment and the things it will do.

There is, however, an unfortunate condition existing, especially in the New England states, which is brought about by a lack of practical knowledge of the process, and, in particular, a lack of knowledge of the metallurgy of iron and steel, as it affects a weld. Among some of the foundries and machine shops in this district, the impression seems to have gained ground that the process produces only a hard, brittle union of the two parts to be welded, and that the weld cannot be machined; also that a weld in cast iron has no particular strength. Nothing could be further from the truth than this impression. It has been brought about by a lack of study of the process, by the use of very poor filling rods, and especially by the use of a great variety of apparatus, with which the market has been flooded which is improperly designed and constructed, and which is directly responsible for failures.

Under these conditions it seems opportune at this convention to consider the process, as applied to foundry work from a more scientific standpoint and with a better understanding of the various features of the apparatus and its use, which bring about success in welding. These various factors cannot be given too much consideration. It is upon them that the success of the process in each individual foundry is dependent.

Preheating of Iron Castings

Iron castings should be carefully prepared for welding, and placed in such a manner that preheating may be accom-

plished without unnecessary handling. This preparation consists in cutting away the edges to be welded to an angle of 45 degrees on each side, to permit the operator to start welding at the bottom of the broken section.

As it is necessary to bring the temperature of the casting up to the point of maximum expansion very slowly and evenly, and as it is desirable to maintain this heat as nearly constant as possible during welding, it is usually best to place the casting in a rough brick enclosure, so the heat may be properly confined.

Preheating should be accomplished either with a large oil or gas flame of moderate temperature, or with charcoal. A fuel oil, or kerosene oil burner, is perhaps the most convenient means for preheating. Two such burners operating through openings in the brick wall above mentioned will usually heat a casting evenly, without overheating any particular part.

During welding, these preheating burners may be shut off, if the heat is found to be too great for the operator, and, when the weld has been finished, they may be relighted and the casting again brought up to an even heat. It should then be completely covered with asbestos, heated slacked lime, hot ashes, or sand, and allowed to cool very slowly. This slow cooling tends to prevent the carbon in the iron from taking the form of combined carbon, which renders the casting hard and brittle.

There are two objects in preheating. The first is to bring the temperature of the casting up to the point where welding may be accomplished with an inexpensive fuel and with a flame or flames which are large enough to heat a large part of, or the whole casting. In this way a good deal of expense is saved, because almost any fuel, like kerosene, fuel oil, or charcoal, costs considerably less and does the work better than oxygen and acetylene. In some instances where the castings are large it would be impossible to bring the casting up to a welding heat with the oxyacetylene torch alone. Second, kerosene or fuel oil torches, or charcoal are used, to heat the casting prior to welding so as to expand it, so it will not crack or be strained on cooling. Such preheating is always necessary where the casting is complicated or where there are several members, in which the movement of expansion and contraction

would be restricted. If these members are not expanded, either in part or whole, before welding; contraction, after the weld has been accomplished, will set up strains in some of the members, eventually, if not immediately, causing a break.

Care must always be taken, however, in preheating a casting to see that it is not heated so hot it will be warped out of shape. This is especially the case where there are machined surfaces, which must be kept true. Preheating should always be accomplished very slowly so that sudden temperature changes and stresses will not be produced. Slow heating is essential especially when the casting is a combination of thin and heavy parts. Cooling in all instances, as stated above, should be accomplished as slowly as possible,

In the first instance, where the casting is large and heavy and has been heated merely to save gas, the temperature to which this preheating may be carried makes very little difference, because this temperature will not ultimately affect the utility of the casting. If desired, it may be heated to a dull red heat. In the second instance, where the casting is complicated, or where there are machined surfaces, which must not be warped out of shape, the temperature of preheating must not be anything like as high as a dull red, but, on the other hand, it must be sufficient to expand the metal properly so that, when contraction takes place, it will not create a strain or break.

Definite rules for preheating are practically out of the question, because in each instance individual conditions govern the method.

Proper Mixture of the Gases in the Torch

In order to produce a proper weld in iron and steel, it is essential that the torch be so constructed that it delivers the two gases, oxygen and acetylene, in proper proportions, and that it thoroughly and intimately mixes these gases.

In every oxyacetylene torch, the two gases are brought together in some manner, the object being to produce a luminous cone of flame at the tip of the torch. If there is just enough acetylene, thoroughly mixed with the right quantity of oxygen, to produce complete combustion; there will be, in the first reaction of the flame, no unconsumed oxygen or acetylene

coming in contact with the weld, and the flame will produce very satisfactory results. But if there is an excess of oxygen, which cannot be consumed in the first reaction of the flame, this excess of oxygen of necessity plays upon the heated metal during the welding operation; and hence oxidizes or burns the metal. If there is an excess of acetylene instead of oxygen, the effect will, perhaps, be less harmful, but the increased amount of carbon, which will be taken up by the metal tends to make the weld hard and brittle.

Before proceeding further with this discussion, it may be well to explain that in the oxyacetylene torch we are consuming oxygen and essentially gaseous carbon. Acetylene contains approximately 93 per cent carbon, the remainder being hydrogen, with the exception of a few impurities, which need not be given consideration.

There are two definite stages of combustion in the oxyacetylene flame; one is termed the luminous cone of flame. In this stage of combustion theoretically one part of oxygen and one part of acetylene burn, and yield hydrogen and carbon-monoxide. In the secondary reaction, which is usually called the enveloping flame, or the envelope, hydrogen and carbon-monoxide burn taking the necessary oxygen from the air and produce water vapor and carbon dioxide. This secondary reaction forms an envelope of burning non-oxidizing gases, which practically surrounds the heated metal during the welding operation and prevents its absorption of oxygen from the air.

It is this enveloping flame and the complete combustion of the oxygen and acetylene delivered by a properly designed welding torch that makes it possible to produce efficient welds.

The opinion seems to have become more or less prevalent in New England, with which the writer is specially familiar, that it is only necessary to lead the two gases together and to control them with two regulating valves in order to produce the required neutral flame. But, a great deal of experience has shown that this is not a fact. The two gases will not mix together intimately when brought into contact and passed through a channel. There must be some other means for mixing them and some definite way to deliver the gases in proper proportion. This is accomplished in properly designed

torches by leading the gases through very small ports of proper diameter, so that the velocity in each instance is high. These ports are arranged at right angles to deliver the jets of gas in fast flowing streams, which strike together and produce a vortex.

In this manner the two gases are thoroughly and intimately mixed before they pass through the tip to the first stage of combustion. They are, also, mixed in as nearly the proportion of one to one as is practicable under working conditions, this proportion being determined by the diameter of the ports leading the gases together and the pressures at which they are delivered. It is, of course, necessary that these pressures be each independent of the other, else the proportion would be out of control.

Properly Constructed Torch

Fig. 1 illustrates a torch constructed upon these principles. The oxygen is led to the east head of the torch through the upper tube under a pressure definitely controlled by the oxygen regulator. The acetylene is led to the cast head of the torch through the lower tube, the pressure being controlled by the acetylene regulator.

The interchangeable tips fit into the receptacle provided in the cast head of the torch by means of a ground joint, and each tip is arranged to produce a different size of flame for use upon different thicknesses of metal. In order that this may be accomplished, the size of the longitudinal bore through the tip and the diameters of the oxygen and acetylene ports must be in proper proportion so that at the pressures given by the regulators, the right amount of each gas will pass through these ports. There is one oxygen port and two or more acetylene ports, the oxygen port being vertical and the acetylene ports horizontal. These ports meet at right angles at the upper end of the longitudinal bore through the tip. The streams of unlike gases, consequently, enter this longitudinal bore under high velocity and strike together creating the vortex we have already described.

Fig. 1 clearly shows the luminous cone of flame produced and also the secondary reaction, or enveloping flame which surrounds the weld. The torch is held by the operator in such

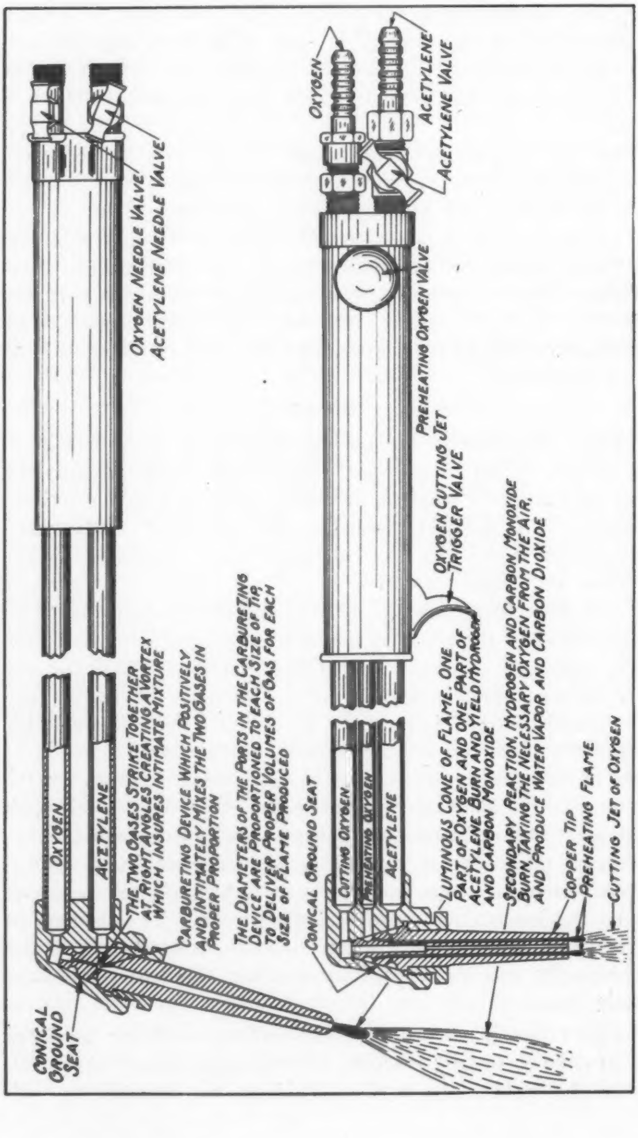


FIG. 1—GENERAL ARRANGEMENT OF A PROPERLY CONSTRUCTED WELDING TORCH. FIG. 2—GENERAL ARRANGEMENT OF PROPERLY CONSTRUCTED CUTTING TORCH

manner that the luminous cone of flame barely touches, or is a short distance away from the metal, which is being welded. It will be very readily understood that if there is an excess of oxygen passing out of the luminous cone unconsumed, it will come in contact with the molten metal, which is being welded and cannot help but produce an oxidizing effect. This renders the weld much weaker than if complete combustion were attained.

It will, therefore, be appreciated that the design and construction of the torch is a very vital factor in the success of the process, and that a positively neutral flame must be secured. Many operators do not appreciate these facts and pay little, or no attention to the character of the flame, and this results in failure which unfortunately cannot always be detected until the weld is placed under a strain.

A little thought on this subject will make it apparent that the two gases must be under a constant pressure to maintain the neutrality of the flame, and that this constant pressure is dependent upon the regulators attached to the sources of supply of oxygen and acetylene. It is, therefore, essential that both regulators be so designed and constructed that these pressures will be steady and even.

Welding Supplies and Materials

In welding cast iron, aside from the importance of preheating and of thorough and proper mixture of the gases in the torch, there is another factor upon which the whole success of the weld is dependent. In making a cast-iron weld, whether the defect is a sandhole or a crack, the metal adjacent the break or hole must be chipped, or v'd, until the included angle between the faces of the break is 90 degrees. After the casting has been properly preheated and the torch applied, the sides of the break are melted away with the torch, and this entire opening slowly filled with cast iron fused into it by melting welding rods held by the operator. The operator ordinarily uses the cast iron rod as a puddling stick, with which he is able to work out slag, blowholes, etc.

The strength of the weld is dependent upon the composition of the welding rod used. It is a well-known fact that silicon in cast iron tends to promote the formation of graphite

making the iron soft. Manganese and sulphur, on the other hand, have just the opposite effect. Cast-iron rods, therefore, should be high in silicon, and the grade of iron used in their manufacture must be of the very best. The rod must be cast

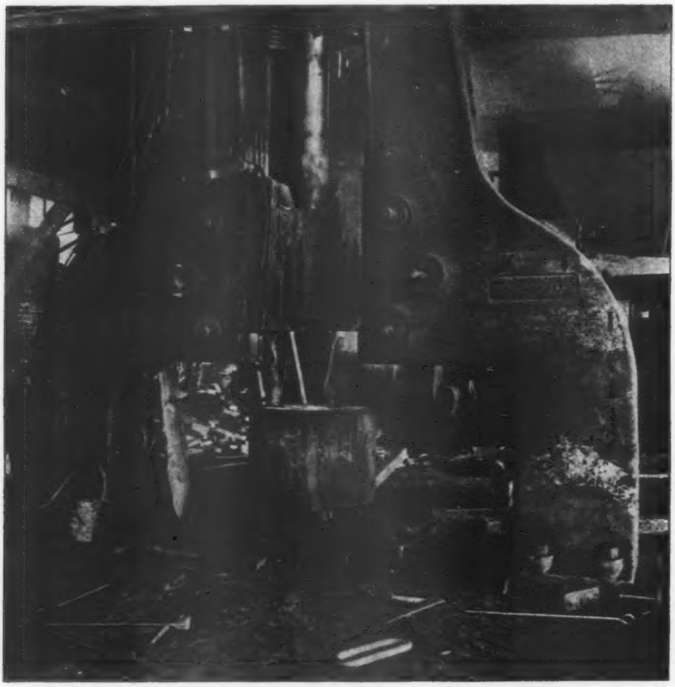


FIG. 3—LARGE STEAM HAMMER WITH WELDED LEG

in a heated metal mold in such manner that it is free from sand and is not chilled on the surface.

In New England, there are a great many cast-iron welding rods upon the market which contain very little silicon and are high in manganese and sulphur. They are, also, of a poor grade of iron, and, of course, are sold at a low price. The use of such welding rods tends to produce white or chilled iron, containing no graphitic carbon, making the weld intensely hard.

The use of proper welding rods increases the amount of silicon in the weld, and decreases the manganese and sulphur, enabling the operator to produce a soft weld, which may be machined without trouble. It would, perhaps, surprise a good many people to know how many jobbing machine shops in Boston will turn down an iron casting if the machining upon it involves the machining of a welded part. Much of this trouble lies in the use of the cheaper grades of welding rods. Even some of the larger companies, who depend entirely upon purchasing agents to buy supplies, price being the only consideration, experience identically the same difficulty, because the welder is utterly unable to produce a satisfactory weld with a poor welding rod.

The manufacture of good welding rods cannot be carried out in an ordinary foundry, as the iron is not suitable for the purpose. The production of such rods is the work of a special foundry, properly equipped, and with accurate knowledge of the requirements.

A good scaling powder is, also, essential in making a cast-iron weld. Melted cast iron has a great affinity for oxygen, which combines with it to form an oxide of iron, or slag. The oxide is lighter than the melted metal and does not melt at quite so low a temperature. As it rises to the surface, a great deal of it can be removed by scraping it away with the welding rod. The object of a flux in this connection is to provide a chemical which at the high temperature involved will break up the oxide into its component parts. The chemicals in the flux combine with the oxygen in the slag, releasing the iron, and allow the oxygen to pass off in the form of carbon monoxide, or carbon dioxide.

When the torch is first applied to cast iron and the metal becomes fused, the molten metal from the two pieces to be welded will not run or melt together on account of the film of oxide covering each mass. The application of a small quantity of flux renders the surface of the metal clear and mirror like, and under such conditions the two masses of metal will quickly flow together in conjunction with the melted welding rod.

If, in the various foundries where cast-iron welding is being accomplished, the foreman in charge of the department

would give more attention to the grade of cast iron rod he is using, his department would be far more successful in producing proper welds. It requires, as a rule, but a few cents worth of welding rods to complete a weld, and the value of an expensive casting may be dependent absolutely upon the strength

FIG. 4—A MORE DETAILED VIEW OF THE WELDED LEG

of the material used. Therefore, a proper rod cannot be considered from a standpoint of price. The best grade of rod obtainable is by far the least expensive.

It is not the purpose in this paper to attempt to refer to or illustrate the many very important pieces of work which have been accomplished by the oxyacetylene welding process. We

are illustrating, however, a particularly interesting piece of work recently completed in Chicago.

Figs. 3, 4, 5 and 6 are reproductions of photographs of a steam hammer, the cast-iron leg of which was broken completely off. The break occurred on a Tuesday morning. On

FIG. 5—A CLOSE-UP VIEW OF THE WELD IMMEDIATELY AFTER THE JOB WAS COMPLETED

Tuesday afternoon preparation of the casting began. It was necessary to chip, or "v", the break clear around the leg. Welding was started on the following Friday and completed on Saturday night. The hammer was assembled Monday morning and put in operation the following Wednesday morning. It has been working day and night, since the break was repaired.

In all, the repair required 16 linear feet of welding in cast iron ranging from 2 to 3 inches in thickness; 2000 cubic feet of oxygen and about 1800 cubic feet of acetylene were consumed. The welding required the services of four men, each relieving the other.

Fig. 6 shows the leg lying flat on the floor of the shop, the break having been enclosed in a rough brick furnace. In

FIG. 6—APPARATUS FOR PRE-HEATING CASTINGS PRIOR TO WELDING

this manner the heat was confined, and the temperature maintained to a very even degree. Preheating was accomplished with large fuel-oil burners. The job is interesting, because it will be readily appreciated that the tensile strength of the weld must, in this instance, have been sufficient to stand up under the very severe strain to which a machine of this type is subjected.

There are many, many other instances of similar work, but in the majority of them, where the castings are large and heavy, the principles of operation remain the same. Care and

skill, good apparatus, and suitable welding supplies are required to make such work successful. The skill, however, is not beyond the intelligence of the average operator, and such skill can be attained without serious difficulty under proper conditions of instruction.

A very interesting application of the process on cast-iron was the welding of the broken cylinders of two of the interned German steamships which were recently taken over by the United States government, and repaired at a certain navy yard. These cylinders were badly broken. In many instances pieces had been entirely removed from them and disposed of. In such instances, it was necessary to recast new parts the shape of the broken ones and weld these new parts into place.

Perhaps, the only way the extent of the welding accomplished on these vessels may be appreciated, would be the consideration of the following list of breaks which were repaired:

First Vessel

Welding crack about 19½ inches long in starboard low pressure cylinder liner.

Welding crack about 27½ inches long in port low pressure cylinder liner.

Welding four broken places each about 8 inches long on end of liners, two on port low pressure cylinder, one on port second intermediate pressure cylinder, and one on starboard second intermediate pressure cylinder.

Welding crack about 12 inches long in cylinder liner of starboard second intermediate pressure cylinder.

Welding about 33 inches on port high pressure cylinder.

Building up about 18 inches on patch on port first intermediate pressure cylinder.

Welding patch about 53 inches on port first intermediate pressure cylinder.

Welding patch about 46 inches on port second intermediate pressure cylinder.

Welding patch about 73 inches on starboard low pressure cylinder.

Welding patch about 73 inches on starboard second intermediate pressure cylinder.

Welding patch about 80 inches on port low pressure cylinder.

Second Vessel

Welding two broken places on flange of elbow about 9 x 3 inches.

Welding flange about 57 x 4 inches on starboard intermediate pressure cylinder.

Welding slide valve of steam chest, 9 x 4 inches on starboard intermediate pressure cylinder.

Welding crack about 12 inches in bushing of starboard second intermediate pressure cylinder.

Welding two pieces on end of flange about 13 x 5 inches on starboard second intermediate pressure cylinder.

Welding patch about 8 x 6 inches on cylinder liner, starboard second intermediate pressure cylinder.

Welding patch about 32 inches in starboard second intermediate pressure cylinder.

Welding patch about 32 inches in starboard high pressure cylinder.

Welding flange about 39 inches on starboard high pressure cylinder.

Welding piece about 7 inches long in steam chest valve of cylinder liner, starboard second intermediate pressure cylinder.

Welding patch about 54 inches on port second intermediate pressure cylinder.

Welding flange about 36 inches on port second intermediate pressure cylinder.

Welding flange about 48 inches on port high pressure cylinder.

This work was all accomplished between June 21 and July 23, approximately one month. It is difficult to believe that it could have been accomplished with any other process, or by mechanical means.

Similar work was attempted with the electric arc, but did not prove as successful as with the oxyacetylene torch. The use of the electric arc, as applied at other navy yards to similar work, necessitated a steel casting, the shape of the broken part, as the arc does not produce satisfactory results in connection with cast iron. The new cast-steel part was attached to the main body of the cast iron cylinder through the use of steel spuds screwed into the casting and set as close together as possible. It will be appreciated that such a joint would be partly a mechanical joint, and partly a welded joint, and could not be expected to be as efficient as a joint which was welded throughout.

As the oxyacetylene torch is especially adapted to welding cast iron, the welding of these cylinders became largely a matter of proper preheating to take care of expansion and contraction. The weld possessed ample tensile strength, and the results were very satisfactory. All the cylinders were carefully tested under rigorous conditions and stood up under severe requirements.

It would be very interesting to show photographs of these broken and welded cylinders, which were taken at the time,

but the necessary permission from the government has not been obtained. It is needless to say that repairs to the two German vessels, in question, have been made with much greater rapidity and at much less expense than if it had been necessary to replace the broken cylinders and parts with entirely new castings.

Cutting in the Steel Foundry

The cutting process is now generally understood by the great majority of foundrymen. It is, of course, not applicable to the iron foundry, but is exceedingly useful in the cutting risers in the steel foundry.

Cast iron cannot be cut with the oxyacetylene torch, but cast steel is quickly and easily cut at a very reasonable cost. It is so much more convenient to take the torch to the castings than to transport a heavy casting to the saws and strap it into position for sawing. Without doubt the cost of sawing a riser is less than the cost of cutting it with the oxyacetylene torch, unless consideration is given to the time required to place the casting at the saw, and the much greater length of time required for sawing. When all factors are considered, including the output of the foundry, a cutting torch is found to be not only an economy but an actual necessity, and today there are very few steel foundries in the country where one or more cutting torches are not in continual operation.

In connection with cutting, as in welding, it is essential that the torch be properly designed and constructed in order to do the greatest amount of cutting with the lowest possible consumption of oxygen and acetylene. A properly constructed torch is illustrated in Fig. 2. As in the welding torches, the two gases are led together through very small ports, under high velocity, but as cutting is an oxidizing process, it is not necessary that the preheating flames be absolutely neutral in character, as is essential to good welding. It is, however, necessary that the gases be applied and the tip of the torch so arranged that the torch will cut cleanly and efficiently any thickness of riser to which it may be applied. This is accomplished with the torch shown in Fig. 2 through the use of interchangeable tips, which are furnished in many different styles, each style suitable for the class of work in view. For

light and intermediate cutting, the greatest economy is obtained through the use of two preheating flames; for heavy cutting, where a good deal of sand is encountered, it is sometimes desirable to use four, or more, preheating flames.

In all probability, cutting apparatus gets harder usage in steel foundries than in other shops, partly due to the class of labor generally operating the torch, and partly to the prevalence of sand in the riser, which causes the oxide to continually flare back. For this reason, to produce successful results and give efficient service, a cutting torch must be very substantially constructed.

The oxyacetylene process in the past 12 years has made progress, which can scarcely be appreciated unless one is thoroughly familiar with each step as it has been developed. Perhaps, this progress is best expressed in terms of oxygen, as the consumption of oxygen is indicative of the use of both welding and cutting apparatus. It is safe to say that 12 years ago there was practically no oxygen consumed in this country, either for welding or cutting. Today a rough estimate of the volume of oxygen consumed in connection with the process is between 40,000,000 and 50,000,000 cubic feet each month.

This development has been so rapid, however, that sufficient consideration could not be given to the proper instruction of skilled operators. In the past most men who have learned to weld or cut have done so despite the difficulties which they encountered and under conditions which did not produce the most successful results. It is without doubt appreciated that today there is more urgent necessity for skilled operators than for development along other lines. This need is being met by the establishment of welding schools where complete courses of instruction are given. The foundryman of today can profit most in connection with the process if he will give careful attention to the kind of instruction given his operators. Even in the case of a skilled welder, a few weeks in a welding school will bring out methods of operation with which he is not familiar, and will teach a great deal which will be new and useful. His efficiency and the efficiency of the process is largely dependent upon his own knowledge and skill in connection with his trade.

Factors Contributing to the Economical Use of Grinding Wheels in the Foundry

By W. T. MONTAGUE, Worcester, Mass.

The modern grinding wheel plays an extremely important part in the metal-working industries. Its great usefulness begins in the foundry just as soon as the newly-poured castings have become sufficiently cool to be removed to the cleaning floor. It is used in the alloy steel industry to remove seams, blisters and flaws from billets, prior to rolling them into commercial shapes. Large numbers are used later on to grind the various metal parts that are fashioned into machine tools, automobiles, aeroplanes, locomotives, war munitions and the multitude of steel tools that are also employed in cutting metals.

Realizing that the grinding wheel is practically indispensable to the foundryman, it is fair to assume that he is vitally interested in those factors that contribute to the economical use of this cutting tool. Although widespread publicity has been resorted to by some of the grinding wheel manufacturers, in order to demonstrate the methods of using and caring for grinding wheels to obtain maximum service at minimum cost, yet there are evidences that there is much to be learned in this direction.

To develop the modern grinding wheel into a tool of usefulness and dependability, has been the abrasive manufacturer's problem, but the problem is not solved when the wheel is produced. The grinding wheel maker must go further than this. He must educate the user so that he can take advantage of all the qualities that science and skill have put into the wheel.

Analysis of the Grinding Wheel Problem

The development of this paper will rest upon the following analysis of factors that will contribute to the economical

use of grinding wheels in the foundry, if they are understood and taken into consideration:

1.—A thorough understanding of the grinding wheel as a cutting tool is the first essential.

2.—The castings to be ground must be carefully considered with special reference to their size and shape, the physical properties of the metal, and the amount of grinding to be done.

3.—The condition of the grinding machines must be satisfactory. This refers to weight and rigidity, solid foundations, adequate bearings and proper lubrication.

4.—The speed of the grinding wheel is of the utmost importance and must be held within certain limits if proper cutting action and economy in wheel consumption are to be obtained.

5.—The personal factor must be taken into consideration and allowances made for it.

6.—Adequate records of wheel consumption should be kept and if conditions warrant, industry and economy on the part of the workmen should be properly rewarded.

7.—The use of the grinding wheel should be made safe by proper protection devices.

The first portion of this paper will deal with the proven theories of cutting action. They will be gone into quite fully, as it is believed the information will be valuable to foundrymen who may be using grinding wheels.

It is a well-known fact that the amount of work one gets out of a machine, engine or tool, is often directly proportional to one's knowledge and understanding of that machine, engine or tool, granting, of course, that the tool is not defective or unsuited to the operation in the first place. This is particularly true of the grinding wheel, which is an aggregation of minute cutting tools bonded together so they can withstand the high rotative speed necessary to rapidly remove large quantities of metal.

The composition of the vitrified grinding wheel, which type is almost always used for snagging castings, is as simple as its manufacture is complex. It is made of abrasive grain, clay bond and water. Subsequent burning in a kiln and heat treatment vitrifies the bond and produces that quality termed "hardness".

The selection of abrasive material is almost entirely dependent upon the nature of the metal to be ground. There have been developed for cutting the metals used in castings today, two principal kinds of artificial abrasive—the aluminous group and the carbide of silicon group. Included in the former are

alundum, aloxite, boro-carbone, adamite, and the like, and in the latter group crystolon, carborundum, carbolite, etc. Without going into the reasons therefor, we will simply state that experience has shown that for materials of high tensile strength, the aluminous abrasives prove the most efficient. This means that the various kinds of steel, wrought iron and annealed malleable iron, automatically call for an abrasive such as alundum. On the other hand, crystolon is chosen for cast iron, including gray and chilled iron, unannealed malleable iron, brass, bronze, aluminum and copper, which are materials of comparatively low tensile strength. This distinction is clear cut and quite easy to remember.

The Question of Grain Size

The question of what size of grain to use is not difficult to settle. The size of the wheel, amount of material to be removed, and the nature of the metal usually determine this very readily. Finish is seldom a consideration and so very coarse grits are used.

How hard to bond a grinding wheel is a point not so readily determined. The influencing factors are many, including:

1.—Physical properties of the metal to be ground
2.—Shape and condition of the surface to be presented to the face of the grinding wheel
3.—Speed of the grinding wheel
4.—Condition of the grinding machine as to rigidity and steadiness of spindle
5.—Method of applying the work, that is, whether mechanically or entirely by hand.

In trying to serve our customers and meet their requirements, we are continually reminded that the question of what constitutes a "grade" or the degree of hardness of a grinding wheel is not fully understood. Grade is the word used to designate relative hardness of any given grinding wheel. By hardness, we do not in this instance refer to the hardness of the abrasive, which is fixed throughout any one wheel. We refer to the strength of the bond in retaining its grip on the cutting grains of the wheel. If the bond is of insufficient strength to hold the cutting particles in the face of the wheel until they have become dulled and worn from the cutting

process, then we call the wheel too soft. On the contrary, an excessively "hard" wheel is one where the bond retains the grit long after it has become dulled and is therefore practically useless. The word "hardness" might almost be called a

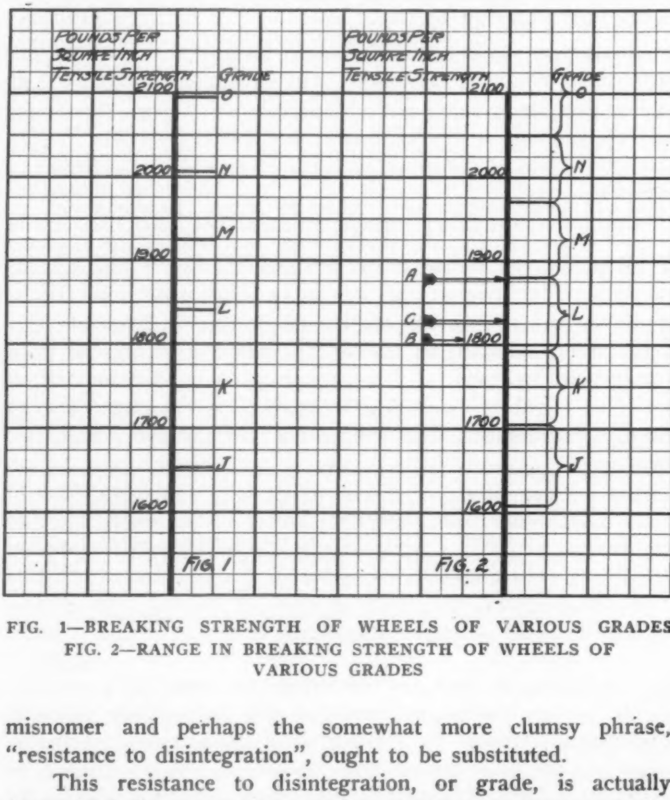


FIG. 1—BREAKING STRENGTH OF WHEELS OF VARIOUS GRADES
FIG. 2—RANGE IN BREAKING STRENGTH OF WHEELS OF VARIOUS GRADES

misnomer and perhaps the somewhat more clumsy phrase, "resistance to disintegration", ought to be substituted.

This resistance to disintegration, or grade, is actually determined by measuring another separate property of the wheel, namely, the resistance of the bond to the penetration of a hardened steel tool. However, it is known that each of these properties is a function of the other and to measure the force of resistance to disintegration in grinding wheels has been impossible on a commercial scale up to this time.

The belief is quite common that a grade is an exact value. A grade is not an exact value or a definite point in the scale of hardness. It is a range between limits and all wheels which test within this range carry the same grade letter.

One way to measure the strength of the bond is to revolve a grinding wheel at increasing speeds until it bursts. Knowing the bursting speed, the centrifugal force necessary to cause the bond to break down can be readily calculated.

In order to obtain Fig. 1, a lot of wheels were speeded up to a point where the fiber stress, due to centrifugal force, exceeded the strength of the bond and breakage occurred. All of these wheels were of the same size, with the same grit, but of different degrees of hardness. The grade *J* broke when the stress was 1650 pounds per square inch, the grade *K* at 1750 pounds per square inch, and so on. Therefore, one might infer that all grade *J* wheels would burst when this same stress was reached.

Not an Exact Value

Now consider Fig. 2 and let us see what really happens when several wheels of supposedly the same grade are tested. We find that those that have been determined to be of grade *J* hardness will burst at stresses ranging from 1600 to 1700 pounds per square inch, grade *M* at from 1880 to 1970 pounds per square inch and so on. In other words, a grade represents a range of values between definite limits. An understanding of this point is most essential to the users of grinding wheels and will explain many seeming variations in grinding wheel action and life.

Assume a certain snagging operation is being performed, whereby all the factors combine to bring a pressure against the grain on the face of the wheel which causes a stress represented by arrow *C*, Fig. 2. Bear in mind that this is a tangential or peripheral stress, so to speak, not a stress due to centrifugal force. The wheel whose bond has a strength represented by arrow *A* will have a longer life than one represented by arrow *B*. This last wheel will not be bonded strong enough to withstand the grinding forces and will wear away quite rapidly, in fact, much more rapidly than the difference in strength or hardness would seem to warrant. This point has been devel-

oped in detail because an understanding of it will eliminate many questions arising between the wheel manufacturer and the wheel consumer. It is needless to say that there is a close limit to the allowable variation and the manufacturer who best keeps within these limits, deserves the greatest confidence of the consumer.

The old idea of grinding considered it as a wearing down

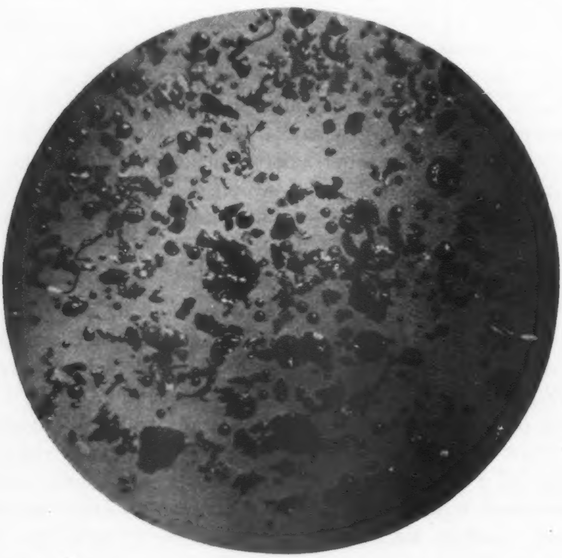


FIG. 3—CHIPS FROM AN UNSATISFACTORY WHEEL OR ONE IMPROPERLY OPERATED

of the metal by rubbing or friction. This is now our understanding of the lapping process and modern grinding has progressed far beyond this point. However, if a wheel is bonded too hard for the work at hand, or if the wheel is too fine or composed of an inferior abrasive, the metal is actually rubbed or burned off, as shown in Fig. 3.

The modern grinding wheel of correct specifications for the work produces chips like those shown in Fig. 4. Its action

is similar to that of a steel milling cutter. On the face of the wheel are millions of cutting teeth at work every minute, and, although these teeth are not as large nor as strong as the teeth of a steel cutter, and cannot cut as deep, they are capable of working at a much greater speed.

In order for a wheel to cut fast and free, it is necessary for it to wear—that is, for the bond to release those grains

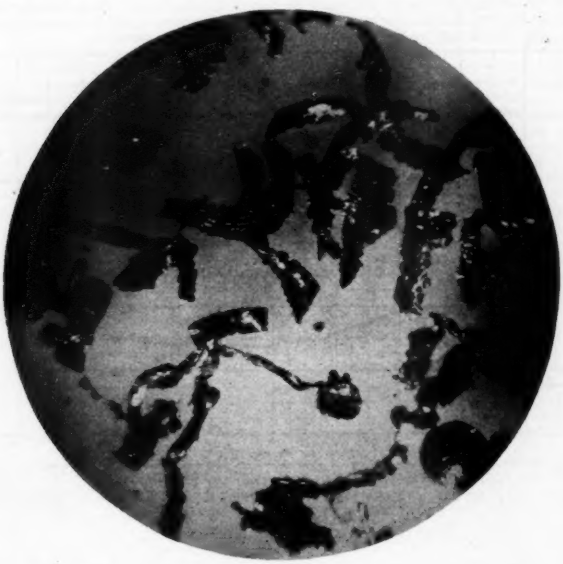


FIG. 4—CHIPS FROM A PROPERLY OPERATING GRINDING WHEEL

that have become dulled and useless. From this it is seen that the grain, which has to the greatest degree the physical property of hardness (we refer to mineralogical hardness), combined with sharpness, is the most efficient and will do the greatest amount of useful work before dulling. It is these very qualities that make alundum superior to the softer and more impure abrasive, emery, which dulls very rapidly under cutting pressures.

A set of experiments recently were carried out, showing

how the condition of the face of a grinding wheel affects its cutting action, its ability to remove metal and the power consumed in doing this. The results are shown in Fig. 5, which represents the curve traced by the stylus of a Westinghouse graphic wattmeter connected to a motor-driven grinding machine. Section A of the curve shows the no-load power. Then

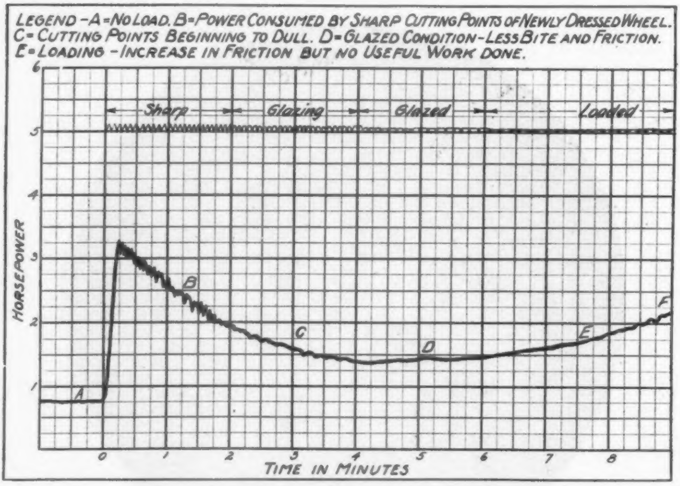


FIG. 5—POWER CONSUMPTION UNDER DIFFERENT WHEEL CONDITIONS

a bar of steel was applied to the wheel under a given pressure and this pressure was held constant throughout the tests. What happened? First, the power consumption climbed abruptly as the sharp cutting grain bit deeply into the metal. After two minutes of this rapid cutting, we reached the glazing point and the line C resulted. At D we were working with a wheel, the cutting points of which were nearly all worn down flat. The power consumption was low because there was practically no useful work being done. The smooth grain simply rubbed and slipped over the bar. At E, the steel began to heat up and get sticky, so that particles began to load and smear into the pores

of the wheel face. These respective conditions of the grains are illustrated diagramatically from left to right above the curve. The power now climbed again, but still practically no useful work was being done. At *F*, or even before this point was reached, the wheel should have been dressed or resharpened. This aptly illustrates the folly of using a wheel that is too

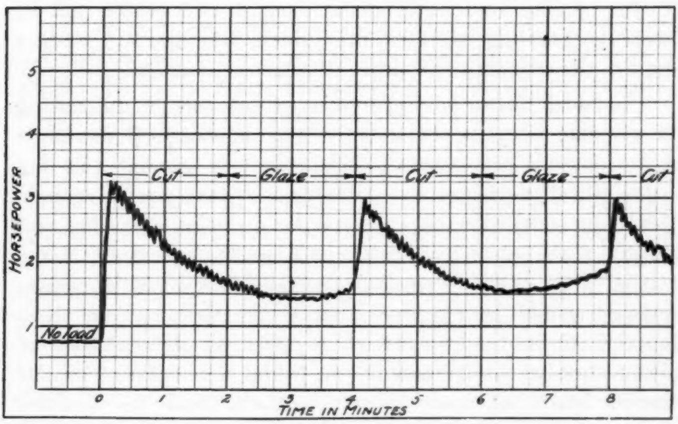


FIG. 6—ACTION OF AN IDEAL WHEEL

hard or dense to cut freely without resorting to continual dressing.

Action of an Ideal Wheel

The action of the ideal wheel is pictured in Fig. 6. This shows that the glazing period is no sooner entered upon, than the bond suddenly gives way and releases the dulled teeth. New and sharp grains take their place and the cutting is resumed at very nearly the initial rate. A wheel of the correct grain and grade for the operation at hand can oftentimes be dressed by the additional application of pressure on the part of the operator, or by presenting the very sharpest fins on a casting to the wheel face under increased pressure. This means that useful work is being performed while sharpening the wheel, with practically no lost time or wear of dresser cutters. It is this condition that all should aim for in selecting snagging

wheels and the workmen should be educated to this kind of grinding.

Some think that in order to make a wheel cut, you must force it exceedingly hard. This is not true, if the wheel is not excessively hard or fine for the work. A wheel of the correct grain and grade will cut faster if you do not force it too hard. If these points are clearly understood, it will enable you to direct the grinding end of your business intelligently. Failure to grasp the essentials will prove disastrous to economy.

The next factor of importance to economy in the use of the grinding wheel in the foundry is a knowledge of the effect of the physical properties of the metal to be ground. To say that a wheel is desired for malleable iron may not be enough. This expression sometimes covers the annealed malleable and sometimes the white iron, before it has been annealed. If the iron is of the annealed variety, then alundum or an aluminous abrasive should be employed, but if the iron has not been annealed, then by all means use crystolon or some carbide of silicon abrasive. Furthermore, the white iron castings usually require wheels of much greater hardness than the annealed castings and this is readily understood when the difference in hardness, density and structure of these metals is known.

It is a common saying that the harder the metal, the softer should be the grinding wheel. Strictly speaking, this applies only to precision grinding, certainly not to the snagging of castings. Let us consider manganese steel, which, as everyone knows, can be machined economically only with abrasives. This material offers a high resistance to penetration and hence, slightly finer grits are usually employed for snagging castings made of manganese steel than would be used for ordinary carbon steel. Coarser grits would require more manual effort than could be expected from the ordinary workman.

Soft, stringy materials generally call for comparatively coarse grits and medium hard grades. Dense, brittle materials require slightly finer grains and harder grades, sometimes one or both.

The following table may illustrate this to a little better advantage:

Metal	Grade of Wheel
Manganese Steel Castings	16-Q or R Alundum Vitrified
Carbon Steel Castings	10-U Alundum Vitrified
Brass Castings	24 Q Crystolon Vitrified
Chilled Iron Castings	16, 20 or 24-S, T or U Crystolon Vitrified

It is no doubt well understood that the harder the fins and the sharper the contact, the harder must be the grinding wheel. This is necessary to counteract the dressing and tearing action of the projecting metal.

Grinding Steel Castings

In grinding steel castings, the breaking-off of gates and risers often leaves a very large volume of metal to be ground away. As the arc of contact thus increases there are increased loading tendencies, and sometimes a heavy, black oil is daubed on the metal, to keep the wheel open and thus reduce dressing. After much experimenting, a specially treated or filled wheel has been developed that automatically lubricates the cutting grains and often greatly lengthens the life of the wheel because of reduced dressing. This filling is not thrown out by centrifugal force; it increases the life of the wheel and many times causes faster cutting action because of the lubrication. In instances where the grinding is of a very rough, heavy nature, this special treated wheel shows up to very good advantage and it would not be economical to use anything else.

We now come to the third factor which has an important bearing on grinding wheel economy, namely, the condition of the grinding machine. Economy cannot be expected if the machines are light and shaky, or if the foundations are not solid. A grinding wheel that vibrates or jumps from any of these causes is soon pounded to pieces by the percussion set up by the castings on the face of the wheel.

A test conducted by an extensive user of grinding wheels for the purpose of determining whether or not it pays to install concrete foundations under the grinding machines, may interest you. This test was conducted with wheels of the same size and same grain and grade, on the very same machines and

identical castings. One set of machines was mounted on concrete or solid foundations and the other on wood or shaky foundation. The results were as follows:

Average life of wheels on wood floor, days	113
Average life of wheels on concrete floor, days	188
Increase in life due to solid foundation, per cent	65
Average saving a month per wheel on concrete floor	$ 2.00
Average yearly saving per wheel	24.00

Where many wheels are used, this saving is a decidedly large and important consideration. In this case, the concrete foundation paid for itself inside of two months and the saving in wheels will go on indefinitely. As it was, several hundred dollars were saved by this company the first year that concrete foundations were used.

Loose and insecure mooring is also detrimental to the life of the grinding wheel. Don't wait until the machine begins walking around the foundry floor before remedying matters.

Similar figures could be produced to show the saving affected by keeping bearings in good condition. Excessive radial play and end play destroy the wheel rapidly. Many times complaints received to the effect that grinding wheels are not standing up as they formerly did, can be traced directly to bearing troubles. The introduction of harder grades, as for example, from grade *S* to grade *U*, only partially remedies matters because the speed of cutting is sacrificed and the operator has to put forth greater effort to do the same amount of work.

Grinding Large Castings

In the case of the medium-sized or large steel foundry grinding quite a variety of castings, it is important to have the grinding machines properly arranged and grouped, so the work may be ground with a minimum amount of handling.

Extremely large castings that must be ground in place should be gone over with wheels mounted on small portable electric, pneumatic or flexible shaft grinding machines. In the case of the electric machines, all that is needed is a convenient lamp socket or a wall terminal.

Next should come a battery of swing-frame grinding machines to handle the medium heavy castings such as drawbars,

locomotive wheels and other similar heavy castings that cannot readily be handled. These machines should be located where prompt crane service is to be had. Then finally, the smaller castings that could be easily handled should be ground on floor stands conveniently arranged.

The proper grouping of machines, segregation of castings, and prompt crane service will make for general efficiency in the cleaning operation. This should be looked out for by a man of good judgment, who could also tell where to grind and where to chip. Much valuable time is lost in trying to chip off fins that could be ground off in a fraction of the time and with much less effort.

A table showing the horsepower required to drive various sizes of bench and floor stands might prove of some help at this point. The values shown in this table were measured under actual service conditions and may, therefore, be considered reliable guides in the selection of motors. The table follows:

Machine	Number of Hangers	Friction H. P.	Total H. P.	Net H. P. Consumed	Size of Motor H. P.	Wheels Used in Test
3/4" Norton Bench Belt-Driven	12	1.08	1.87	0.81	2	2-10x3/4 at 5000 S.F.P.M.
1 1/4" Ransom Bench Direct-Connected	2	0.75	3.00	2.25	3	2-12x1 1/4 at 5000 S.F.P.M.
1 1/2" Norton Floor Belt-Driven	5	0.95	3.88	2.93	4	2-16x1 1/2 at 5000 S.F.P.M.
2" Norton Floor Belt-Driven	11	1.30	4.75	3.45	5	2-24x2 1/2 at 5000 S.F.P.M.
10"x72" Norton Cylindrical	2	2.50 TO 3.00	10.00	7.50	10	1-18x2 at 5000 S.F.P.M.

Much has been said and written about proper operating speeds for grinding wheels, but perhaps some important phases of this subject have not yet been made thoroughly clear. Generally speaking, the correct speed ranges for the grinding wheels used in snagging castings lie between 5000 and 6000 surface feet per minute. This is fairly well established and quite generally accepted by the manufacturers of grinding wheels. This range was determined partly by long years of

experience and partly by physical laws and the desire for an adequate factor of safety. The engineer building bridges, steel structures, machines and what not, recognizes the necessity for an adequate factor of safety and makes due allowance for it. Similarly, the engineer in making grinding wheels sees the great necessity for a factor of safety in operating speed. All snagging wheels made by reliable manufacturers are subjected to a speed test the last minute before being packed that generates a centrifugal stress many times in excess of the stress prevailing under the recommended operating speed. In the case of the Norton Co., this tested factor of safety runs from 2¼ to 3¼. This, then, is the first limiting factor to wheel speed.

Furthermore, it has been shown there is no appreciable gain from faster speeds, at least not enough gain to offset certain drawbacks. It should be further remembered that the grinding wheel is designed to operate at approximately the recommended speeds and any appreciable deviation calls for adjustments that are not always easy to make or conducive to efficiency.

Keep Surface Speed Constant

It is now common knowledge that it is necessary to keep the speed of the grinding wheel approximately within the recommended range, if its productive capabilities are to be maintained. It has been demonstrated that if a wheel's speed is allowed to fall to a very low level, or if it is speeded up beyond a certain point, in both cases reduced cutting ability for the same amount of effort expended is the result. In the case of a sub-normal wheel speed, not only does the productive capacity fall off, but also, there is excessive wheel wear.

To illustrate this point, let us consider the case of an 18-inch wheel, 10 grade *U* alundum, used for snagging steel castings. At 1175 revolutions per minute its peripheral speed is 5500 surface feet per minute, and it cuts and wears satisfactorily. If the revolutions remain the same, at 11 inches diameter, the surface speed is reduced to 3500 feet. What is the result? Every cutting grain on the face of a revolving grinding wheel has a definite amount of energy stored up in it. It is the expenditure of this energy that enables the grain to do

useful work and remove metal. Now the energy available varies as the square of the surface speed. Therefore, at 11 inches diameter, the cutting grains have only 40 per cent of the energy that they had at 18 inches diameter and they cannot be expected, therefore, to grind as rapidly. Also, because of the decreased energy stored up in each grain of abrasive, it is less capable of withstanding the resistance offered by the steel

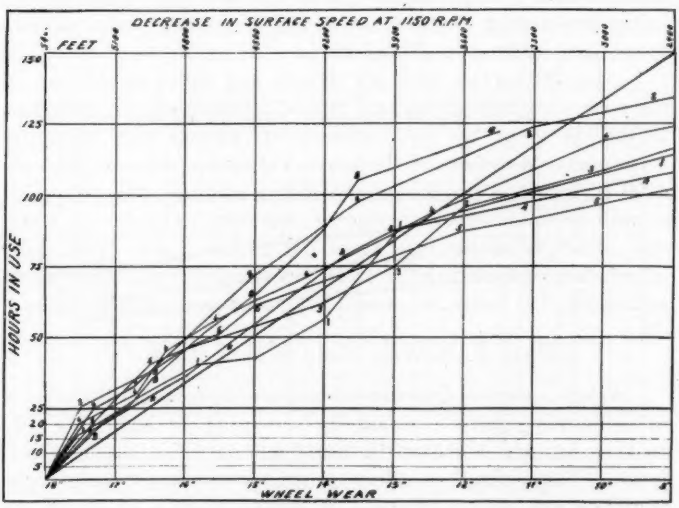


FIG. 7—RELATION OF LIFE OF WHEEL TO SPEED

and hence is more readily torn from its setting. This, then, explains the difficulty that will be encountered in attempting to grind at very low surface speeds.

On the other hand, if this same 10 grade *U* alundum wheel was giving satisfaction at 5500 surface feet per minute, and an attempt were made to speed it up to 7000 surface feet, no greater production would be realized. This is due to the glazing effect resulting from the increased duty imposed on each abrasive grain.

Keeping a fairly constant surface speed by increasing the revolutions as the wheel wears down, is the proper procedure

for maximum cutting ability with minimum wear. This relation of life of wheel to speed is perhaps more clearly indicated in Fig. 7, representing actual results of tests conducted in a large foundry. The curves show the rate of decrease in wheel life as the surface speed drops off. The continuous straight line is for a wheel lasting 150 hours, wearing uniformly from 18 inches to 9 inches in diameter. Surface speed at the start was 5400 surface feet per minute, and, the revolutions per minute being maintained constant at 9 inches diameter, the surface speed was reduced to 2700 feet.

At 5400 surface feet per minute and full diameter, all of the wheels tested start off at a 200 or 250-hour pace. However, before the speed has been reduced 300 surface feet, we notice a change in the slope of the curve indicating reduced life. At 4000 surface feet per minute, 13 inches diameter, the falling off is most pronounced and instead of obtaining 150 hours of wheel life, it ranges all the way from 100 to 135 hours. Had these wheels been speeded up at 15 inches diameter and again at 12 inches, the 150 hours life would have been more nearly attained.

What Excessively Hard Wheels Lead To

When a user of grinding wheels wishes to avoid the trouble of maintaining fairly constant surface speed, he invariably tries to keep his wheel life up by using wheels of excessively hard grade. The immediate effect of this is increased power consumption and decreased speed of cutting, neither of which are desired. Fig. 8 shows that regardless of speed, successively harder grades require more and more power to remove the same amount of material.

It is, therefore, quite evident from the foregoing that economy in wheel life comes from maintaining fairly constant surface speed as the diameters of the wheels are reduced. This can be brought about by using variable speed motors, or having machines running at graded speeds, to which the worn wheels are shifted at given sizes.

The next point that requires careful consideration is the personal factor entering into the use of snagging wheels. No two men will get the same life or production from a grinding wheel, even though the work and conditions are identical. If

the foundry is large and there is a constant duplication of work so that the piece rate can be used, then it is safe to say that harder wheels must be used than where day rate compensation is in force. However, the ideal condition that permits the wheelmaker to specify a free-cutting wheel, is where there is a premium paid for maximum production with minimum wheel wear.

Some men work the corners of the wheel hard, others are abusive in applying the castings, and still others think they must remove a quarter of an inch of abrasive in dressing, where a

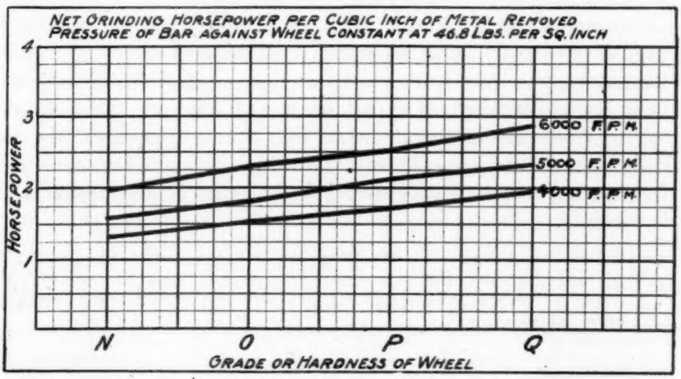


FIG. 8—RELATION OF HARDNESS TO POWER CONSUMPTION

sixteenth of an inch would be ample. All of these factors have their effect, and must be allowed for. It is, therefore, important that some kind of a record should be kept, showing just how each grinder uses his wheels. Many times the grinding wheel manufacturer is blamed unjustly for apparent variations in wheel life and hardness. In some of these instances the true causes can be attributed to the operation of this personal factor. For instance, if a wheel should happen to be on the soft side of grade *S* and it should get into the hands of a grinder who was very hard on grinding wheels, a certain life and production would be obtained. Now, in the same lot of wheels, there might be one that varied slightly the other way or toward the hard side of grade *S*. Suppose that this was used by a man

who was more careful in using his wheel. It is evident the wheel would last very much longer under these conditions and hence from a very slight and permissible variation in hardness of wheel, we get a result that would indicate a wide variation, if the personal factor is not considered. This is not idle speculation. It is stated from observation of actual cases.

Where there is a constant duplication of work and the piece-rate is used, there is a very simple but serviceable method for computing the relative efficiency of various grinding wheels and operators. The operator's earnings on a given class of work per dollar cost of wheel may be considered, under these circumstances, as a very fair means of determining the efficiency of the particular wheel used. To encourage operators to use their wheels economically, a bonus or premium is sometimes paid for all earnings in excess of a given figure. This works out very satisfactorily and means that the competent grinder is rewarded for his competency. It also invariably means that free-cutting wheels will be used and hence maximum production is obtained.

Records on Snagging Castings

Here are some actual figures obtained from snagging wheels that are interesting:

Life, Hours	Weight of Castings Pounds	Average Per Hour Pounds
127	26,543	208
157½	27,043	172

If no records were kept, the wheel with longer life and slightly greater total tonnage, would undoubtedly have been picked as the more economical to use. However, the wheel with 127 hours life produced 20½ per cent more castings a day and the profit on this increased production more than offset the slightly increased abrasive cost.

Another large consumer of snagging wheels keeps a tabular record on printed cards of the following: Date; pieces ground; weight, pounds; hours of grinding; earnings; and wheel loss on diameter. These figures permit the calculation of the abrasive cost per ton of castings ground, and the earnings per ton of castings ground. Manifestly, it is desirable to keep the abrasive

cost as low as is consistent with satisfactory earnings per ton. Keeping such records as these makes it easy to pick out the correct grinding wheel, and enables the foundryman to tell just what each of his grinders are doing. He can also tell what the wheel manufacturer is sending him, without guesswork, or resorting to hearsay evidence from a few of the operators. This is decidedly practical and works for economy. It is time large foundrymen paid more attention to this phase of manufacturing cost, for nowhere is it easier to save or lose large sums than in the cleaning operations where grinding wheels are used.

Here is an example which shows that it is worth while to keep adequate grinding records. A certain large producer of draw-bars was using a hard wheel, 10-*W* alundum. It had fairly long life and turned out a large number of bars before it was used up. On the other hand, the grinders were continually complaining that they had to work too hard and dress too often. Finally the grinding wheelmakers were called into consultation and a test carried out with several different grains and grades of wheel. The result was the choosing of a 10-*U* alundum wheel, one grade softer than the *W*. The complaints ceased as soon as this wheel was put into general use in the foundry, and although the wheels were used up faster, the production was greatly increased and the overhead correspondingly reduced. A brief analysis of this will show up the facts to better advantage:

	Hard Wheel, 10-*W* Alundum	Soft Wheel, 10-*U* Alundum
Grinding cost per ton ground	$0.49	$0.55
Total number pieces ground	1800	800
Pieces ground per hour	8	10.2

The use of the softer wheel increased grinding cost 12 per cent, but increased production 27 per cent and lowered overhead charges because of the increased tonnage turned out in the same time with the same equipment.

Every foundryman who operates a foundry of any size should try and work out a system that would apply to his particular conditions. Let him consult the wheelmaker if necessary and take advantage of whatever experience he has acquired in handling many similar problems. It does not cost very much

to investigate, but it is decidedly expensive to continue operating year after year with inefficient and wasteful methods of snagging and cleaning.

Make Your Wheels Safe

A discussion of grinding wheel economy would hardly be complete without some mention, at least, of the necessity of making the use of this tool safe. It is not economy to allow the work to get jammed in between the wheel and the rest, because the wheel undoubtedly would be broken. This is prevented by keeping the rests adjusted close up to the face of the wheel. It is not economy to have one or more grinders going to the hospital every little while to have a foreign body removed from the eye. This can be prevented by supplying an approved type of glass goggle, making the men wear them while grinding. Much trouble also has been caused from flying pieces of chilled iron dresser cutters, which break in the dressing operation. This can be eliminated by using hooded dressers. State laws are beginning to call for closer attention to such features.

Apart from the humanitarian side of this question, it is undoubtedly more economical to employ safeguards where rapidly revolving grinding wheels are used than to trust to chance that there will be no accidents. The cleaning of castings is heavy and wearing work at best, and the least that the foundryman can do is to make the working condition as safe and bearable as possible.

Experiments to Determine the Most Effective Means of Mixing and Blending Foundry Facing Sands

By R. F. HARRINGTON, Boston

The study of the reclamation of molding sands has, I believe, received considerable impetus within the past few years, especially in gray iron foundries, because of the increasing cost of raw material and dumping charges. Most of this study has, however, been put merely upon the development of machinery for recovery of the waste sand, with very little attention, so far as I am able to learn, upon improved means of mixing or blending. The recovery of the waste product was sought after rather than a more efficient mixing which would, from the start, demand less new material. Both propositions have, however, one main idea, namely that of increasing the tonnage of castings produced per ton of new sand used.

Some four years ago in a conversation with Dr. Richard Moldenke relative to a certain facing sand it was suggested that the sand might be bonded up or strengthened by the use of a very plastic fire clay. From the results of experiments conducted along these lines it was very evident to the writer that the use of clay, to any great extent, was limited, without the use of a better means of mixing or blending.

Up to the time of this realization, clay had been added to the heaps with some success in amounts up to 2 per cent. Having come to the conclusion that further additions of clay in amounts over 2 per cent were not successful, a series of experiments was undertaken for the purpose of determining mixtures and means of blending which would permit the use of larger portions of clay, with a consequent reduction in the amount of new material added.

Before entering upon the main discussion, I will digress to describe the three methods of sand testing which were used throughout the investigation.

The first two, or the so-called bond and sieve test, are devised to determine in the one case, the amount of active clay substance present in the sand, and in the other the relative grain sizes and the percentage of clay substance. In the first

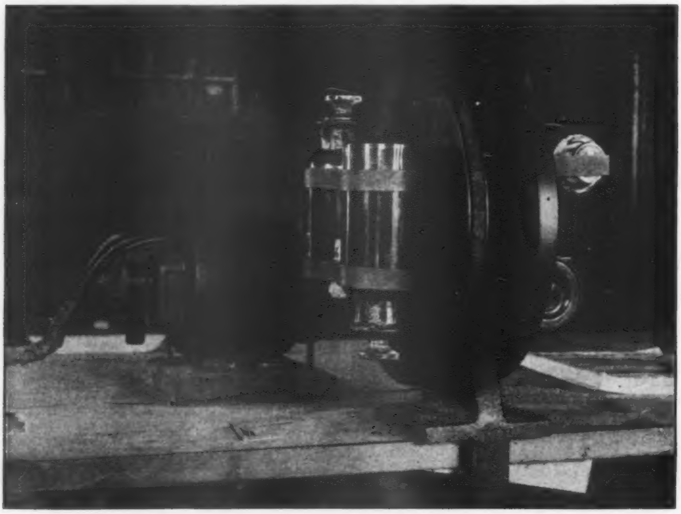


FIG. 1—SHAKING APPARATUS FOR MIXING SAND WITH DYE

instance, the amount of clay substance is obtained by measuring the amount of crystal violet dye absorbed by the clay present; in the other case the relative grain sizes and the percentage clay substance is obtained by putting the sand in question through a series of standard sieves, reporting as the per cent of fineness the amount of sand retained on each sieve.

Originally Suggested by Dr. Moldenke

These two tests, as conducted, were primarily the same as those originally suggested by Dr. Moldenke and later revised and improved upon by Messrs. Saunders and Hanley of

Providence, R. I., as outlined in their paper before the Atlantic City convention in 1915.

For those not familiar with the tests as described by these gentlemen I would point out that the bond test as conducted consists of subjecting a given weight of the new molding sand, facing or heap sand to the action of a so-called deflocculating agent, whose function is to break up the sand conglomerates, separating the clay and sand particles in such a way as to allow more intimate contact with the dye solution, which is later added. Agitation with the deflocculating agent and the

FIG. 2—TRANSVERSE TESTING MACHINE

known amount of dye is brought about by a standard shaking apparatus, as illustrated in Fig. 1.

After allowing the suspended particles to settle, the amount of dye which remains unabsorbed is measured either by comparison of the depth of color of the supernatant liquid with the depth of color of a standard solution by means of color comparison tubes or by dyeing skeins of cotton yarn with the unabsorbed dye solution followed by comparison with standard cotton skeins.

Thus, by obtaining the difference between the amount of dye unabsorbed and that originally added we are able to arrive at the amount of dye actually absorbed by the active clay sub-

stance present, whether it be the active clay substance in the new molding sand, facing sand, or clay. The result is usually expressed as the milligrams of dye absorbed by 100 grams of sand, the bond number varying in the case of sands from 300 to 1200 and in the case of clay from 1700 to 5000.

The sieve test consists of subjecting a known weight of sand to the action of a deflocculating agent as in the bond test and then separating the various sized grains by collecting them on sieves of 20, 40, 60, 80, 100, 150 and 200 mesh. Since all the clay substance and some of the sand grains are smaller than 200 mesh it is necessary first to transfer the sample to the 200 mesh sieve and wash with a stream of water. The sand particles passing through the 200 mesh sieve, which are termed 200 plus mesh, are separated from the clay substance by allowing the sand grains to settle and the solution containing the suspended clay particles is then decanted.

The residue collected on the 200 mesh sieve is then transferred to a dish, the sieves stacked, and the residue transferred to the upper one. Washing is continued until the particles have been retained on their respective sieves when they are dried in an air bath and weighed. As stated above, the weight retained on each sieve is recorded as the per cent of fineness. The amount of clay substance is then determined by obtaining the difference between the total 100 per cent and the sum of the per cents retained on the sieves.

The third or the transverse strength test is merely devised to measure the breaking load of a standard bar of molding sand or clay, and is to a considerable extent, a measure of the strength of the binder, whether this binder consists of the active clay substance present in the new sand added, or an artificial binder which might be added as in core sands. The bar used is 6 inches long and 1 inch square in cross section. The testing machine consists of a pair of knife edges 5 inches apart on which the bar to be tested rests. A load is applied at the center through a knife edge and lever system. The load is applied to the beam by means of a stream of shot which enters a bucket container. By weighing the shot the actual load in grams required to break the bars is obtained. Fig. 2 illustrates the testing machine.

Below are given specimens of sand test records:

Green Jersey Shipment 5-3-16		Laboratory Mixture 2-23-17		Red Spotted Clay
Bond No. 576		Bond No. 466		Bond No. 3050
Mech. Analysis		Mech. Analysis		
Mesh	Per Cent	Mesh	Per Cent	
20	8.46	20	15.28	
60	18.70	40	22.80	
40	19.12	60	17.00	
80	9.26	80	7.36	
100	4.70	100	3.40	
150	7.26	150	5.20	
200	3.00	200	1.04	
200	13.24	200	11.52	
Clay Substance	16.26	Clay Substance	16.40	
	100.00		100.00	
Transverse Strength, — grs.		Transverse Strength, 660 grs.		Transverse Strength, 5160 grs.

So much for methods of analysis.

First Step in Investigation

The first step in the investigation was to obtain the bond tests and mechanical analyses of the new molding sand and old material entering the different mixtures throughout the shop. Having obtained these results in order to ascertain like results on the mixtures employing these sands, which, although costly, were satisfactory so far as the castings produced were concerned, bond tests and mechanical analyses were run for a period of one month.

Working, then, on the theory that good castings would result, other things being normal, if the proper bond and mechanical analysis was maintained, a number of cars of the same molding sand as previously used, but carrying 20 per cent higher bond, and this at no increased cost per ton, were obtained. This sand replaced the sand formerly used and because of the high bond or active clay substance present, allowed the use of 10 per cent more old sand in the mixture. This sand was prepared as was the former mixture by merely cutting over

the new and old material, tempering and putting it through a No. 4 Riddle.

Below is recorded the two facing mixtures with bond test of component parts together with transverse breaking load:

Original Mixture

Constituent Per Cent	Bond	Contribution to Mixture
72 Jersey No. 3	475	342
20 Old Sand	275	55
8 Sea Coal		
	Total Bond	397

Transverse Strength, 1320 grams

Mixture No. 1

Constituent Per Cent	Bond	Contribution to Mixture
62 Jersey No. 3	570	353
30 Old Sand	275	82
8 Sea Coal		
	Total Bond	435

Transverse Strength, 1188 grams

It is noted that although in mixture No. 1 the amount of new sand added is 10 per cent less than in the original mixture the total bond is approximately 10 per cent more. This, of course, is due to the 20 per cent more bond initially obtained in the new sand entering mixture No. 1, and, as stated above, this increased bond per unit of new sand added was made possible by the selection for this use of a molding sand containing a higher percentage of active clay substance.

Active Clay Substance

To make clear what is meant by the amount of active clay substance, I will take for example two mixtures of sand. One mixture contains 95 pounds of silica sand of a definite mechanical analysis and 5 pounds of flinty clay. It is designated as mixture *A*. The other, designated as mixture *B*, makes use of 95 pounds of the same silica sand, but instead of 5 pounds of flinty clay makes use of 5 pounds of Jersey (Woodbridge) clay, which is rated as 100 per cent fat by the geological survey.

A mechanical analysis of these two sands would show in both cases 5 per cent of clay substance. Yet in one instance we would have a bond test of 250 and in the other a bond test of 125. This, of course, is due to the fact that the Woodbridge clay shows a bond test of 5000 as compared to a bond test of 2500 in the case of the flinty clay. This is easily noted in the tabulation which follows:

Mixture A

Constituent Per Cent	Bond No.	Bond Contribution
95 Silica No. 1	None	
5 Clay (Woodbridge)	5000	250
	Total Bond	250

Mixture B

Constituent Per Cent	Bond No.	Bond Contribution
95 Silica No. 1	None	
5 Flinty Clay	2500	125
	Total Bond	125

From mixture No. 1 containing only 62 per cent new sand there were made 100 castings which, so far as outward appearance and clean metal on machining were concerned, compared very favorably with castings made from the original mixtures containing 72 per cent new sand.

A step in the right direction having been made so far as the use of more suitable sands was concerned, a mixture was devised as noted below which employed 1½ per cent of clay for the purpose of reducing the amount of new sand necessary to supply the required bond. This mixture is as follows:

Mixture No. 2

Per Cent	Constituent	Bond	Bond Contribution to Mixture
47	Jersey	570	268
44	Old	275	121
1½	Clay	3000	45
7½	Seacoal		
100		Total Bond	434

Transverse Strength, 678 grams

Here although the proper bond and texture had been maintained, scabbing was encountered on a large number of the castings. A careful study of the mixture as prepared for use on the foundry floor revealed the fact that the clay added had not been properly mixed and when slicked with the trowel had caused a sputter when in contact with the hot metal. In an endeavor to overcome this difficulty a mixer of the paddle

FIG. 3—MULLER USED IN SAND BLENDING TESTS

type was employed. By means of the much more thorough mixing obtained in this machine, the difficulty of scabbing was overcome to a great extent.

A further attempt, however, to decrease the amount of new molding sand necessary by the use of further clay additions showed conclusively that the limit had been reached unless a more complete blending of the component parts was made possible by some other type of machine.

A careful review of the results of the above experiments developed certain important facts, namely, that while the

mixer gave a more complete mechanical mixture as compared to the hand prepared facing sand and at a less cost per ton for mixing, it did not permit the use of any less new material than a well prepared sand mixed by hand. In other words, there was nothing to be gained in the operation of the mixer insofar as use of less new material was concerned, the only advantage being in the fact that it usually permitted the same mixing at a less labor cost per ton. A careful study of the mechanically and hand mixed sands under the microscope revealed no marked difference, insofar as the coating of the

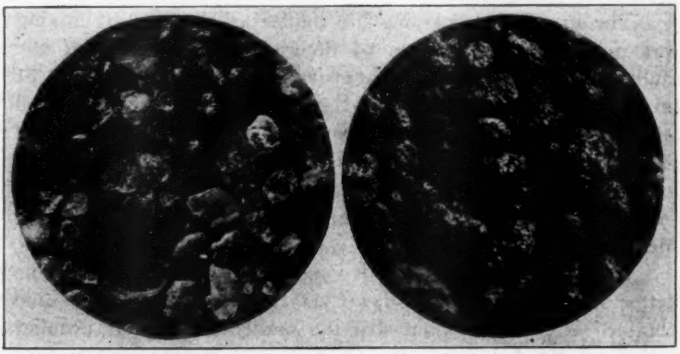


FIG. 4—MICROGRAPH OF SAND PRIOR TO BEING COATED WITH CLAY IN THE MULLER

FIG. 5—MICROGRAPH OF SAND AFTER BEING COATED WITH CLAY IN THE MULLER

burnt grains of sand with the new sand and clay was concerned. Results of the breaking of transverse test bars also revealed no greater tenacity of the grain particles, which would be a criterion of the thoroughness of mixing.

With the necessity in mind of increasing the efficiency of all new material used in the facing by more complete blending, a so-called pan muller was purchased for this purpose. This, one might describe as a machine consisting essentially of a cylindrical pan, with a bottom of cast iron, about 5 feet in diameter and sides of sheet steel about 1 foot high. Resting on this pan are two heavy cast-iron rolls approximately 2 feet in diameter and 8 inches wide. These rolls are held in posi-

sition by guides which allow revolution only about their respective axes due to contact with the pan and its contents, as shown in Fig. 3.

While awaiting the arrival of the muller, the mixture designated as No. 2 was run in the foundry for a period of two months. This mixture, which made use of 1½ per cent of Jersey fire clay together with a high bonded Jersey sand was mixed in the paddle type mixer. Eventually it replaced the mixture previously used with a consequent saving of approximately 22 per cent of new material, or approximately 95c per ton of facing mixed.

The first test employing the muller as a means of mixing was made for the purpose of determining the effect of the mulling action on the character of the facing. The effect of this action, so far as increased efficiency of all new material added is concerned, is best shown by a study of the tabulated results which are recorded below. They represent the breaking loads on three sets of bars made from the same mixture of sand but mixed by hand, in the mixer, and in the muller, respectively.

From the following data it is seen that the mixer offers no better means of mixing so far as the strength of the sand obtained is concerned, but that the muller does by its peculiar action offer a far more efficient means of mixing or blending. In support of this theory, illustrations showing the manner in which a sharp sand is coated with clay by the action of the muller are presented in Figs. 4 and 5.

The results of the tests are as follows:

Hand Prepared Mixture No. 1		Machine Mixture No. 2		Muller Mixer No. 3	
Bars	Ounces	Bars	Ounces	Bars	Ounces
A	9.5	A	10.	A	12.5
B	10.5	B	9.5	B	13.5
C	10.5	C	10.5	C	14.5
D	10.5	D	11.0	D	12.5
E	10.	E	9.5	E	10.5
F	11.	F	10.	F	14.
G	10.3	G	9.5	G	14.
H	10.	H	10.	H	12.
I	10.	I	10.	I	13.
J	11.	J	10.	J	12.
Average 876 grs.		Average 852 grs.		Average 1107 grs.	

The first sand mixtures for facing purposes prepared in the muller varied in clay content from 1 to 7 per cent and in new sand content, from 10 to 50 per cent, these mixtures making use of varying proportions of new sand and clay, in some instances consisting of clay and old sand only and in other instances, of only new and old sand.

Long Series of Experiments

This long series of experiments was made necessary because of the entirely new action obtained in the muller with its consequent effect upon the character of the facing and its action when in contact with the hot metal. At this point in the work it was found that the bond test was not the best criterion of the strength of the sand, the change in the method of preparation so increasing the effectiveness of the mixing as to make the bond test on the different facings no longer comparative.

The transverse strength and mechanical analysis were found to be the most satisfactory means of judging the character of the different heaps, the bond test in such an instance giving only the amount of active clay substance present while the transverse strength not only indicated the amount of active clay substance present, but indicated the character of effectiveness of the mixing.

The bond test, however, was continued as a means of measuring the strength or active clay substance in the new sands and clay received.

After months of experimenting and extended use of many different facing mixtures, mixtures Nos. 3, 4 and 5, as noted below, were, after trial in the foundry, adopted as satisfactory:

Mixture No. 3

Per Cent	Constituent	Bond	Contribution to Mixture
60	Old Sand	275	165
30	Jersey Sand	570	171
3½	Clay	3000	105
6½	Sea Coal		
		Total Bond	441

Transverse Strength, 1065 grams

Mixture No. 4

Per Cent	Constituent	Bond	Contribution to Mixture
57	Old Sand	275	157
15	Jersey Sand	570	86
20	Millville Gravel	700	140
8	Sea Coal		
		Total Bond	383

Transverse Strength, 930 grams

Mixture No. 5

Per Cent	Constituent	Bond	Contribution to Mixture
57	Old Sand	275	157
20	Beach Sand		
15	Millville Gravel	700	105
8	Sea Coal		
		Total Bond	262

Transverse Strength, 630 grams

These mixtures all received 1½ minutes mulling action, and although prepared for different classes of castings, they are based on the same principles throughout, namely, the use of such proportions of new sand, old sand and clay as to give a facing which would not, when in contact with the metal, be subject to scabbing or blowing. Mixture No. 5 illustrates the necessity of using a sharp sand to give proper texture and working qualities.

A study of the foregoing mixtures as compared to the mechanically and hand prepared mixtures, again reveals the fact that a much lower active clay substance is necessary, the mulling action giving sufficient strength to the facing, as noted by the breaking loads of the transverse bars.

In conclusion the writer offers the following comparative new material costs of the different mixtures:

Original Mixture		Mixture No. 1	
72% Jersey @ \$4.00	\$2.88	62% Jersey @ \$4.00	\$2.48
8% Sea Coal @ \$9.00	.72	8% Sea Coal @ \$9.00	.72
	\$3.60		\$3.20

Mixture No. 2

47% Jersey @ $4.00	$1.88
1½% Clay @ $7.00	.11
7½% Sea Coal @ $9.00	.67
	$2.66

Mixture No. 3

30% Jersey @ $4.00	$1.20
3½% Clay @ $7.00	.25
6½% Sea Coal @ $9.00	.58
	$2.03

Mixture No. 4

15% Jersey @ $4.00	$0.60
20% Millville @ $4.00	.80
8% Sea Coal @ $9.00	.72
	$2.12

Mixture No. 5

20% Beach @ $1.60	$0.32
15% Millville @ $4.00	.60
8% Sea Coal @ $9.00	.72
	$1.64

These figures, it is believed, are sufficient to show the worth of such a series of experiments as outlined above. As to the merits of the different types of machine for mixing or blending, the writer most heartily recommends the muller as being in his opinion the machine which, because of its more effective blending, will allow the use of the minimum amount of new material.

Discussion

Mr. Luther G. Conroe:—In order that practicing foundrymen may intelligently judge the value of the foregoing experiments as a help in purchasing mixing equipment it is only fair that it be pointed out that the shovel type of mixer used by Mr. Harrington was not a mixer that is sold on the market.

We certainly commend Mr. Harrington for his appreciation of the importance of investigating the efficiency of various methods and equipment used for mixing foundry sands, but such an investigation should be made with several makes of equipment for sale on the market. Otherwise, the results do not at all prove the relative efficiency of the shovel and muller types of machines.

Mr. John Shaw:—In my judgment, Mr. Harrington's recommendations are all right if the sand used is coarse. I worked along these lines some years ago and obtained good results for more than six months, then the castings developed scabs, due undoubtedly to the gradual reduction of the old sand to fine dust. His method would not give satisfactory service, say for example, on Erith sand. A test for Erith and Jersey sands follows:

Mesh	Erith Per cent	Green Jersey Per cent
20	....	8.46
30	0.192	....
40	....	19.12
60	0.840	18.70
80	....	9.26
90	0.280	....
100	....	4.70
150	38.876	7.26
200	....	13.24
*Washed through 150 mesh sieve.	58.088	....

*This amount was washed through 150 mesh sieve, no clay being taken.

The ultimate analysis of Erith sand follows:

Constituent	Per cent
$Si\ O_2$	88.25
Al_2O_3	7.70
FE_2O_3	2.50
Ca O	0.72
Mg O	0.58
Loss	1.00

I think a comparison of the two mechanical analyses will at once show why the muller cannot be used on the English Erith sand. When I obtained samples of sand several years ago I found few firms who could use the muller with safety because English sands are so fine. We all recognize that mulling does strengthen the sand but at the same time it grinds it, reducing so large a part to dust, so permeability is lost. The clay content is so variable, at least in England, that nearly every load varies.

The Centrifugal Compressor for Cupola Blowing

By J. A. Shorey, New York

The centrifugal compressor has demonstrated its value for cupola service to such a degree that there is today among foundrymen who have had experience with it no doubt regarding the advantages of this type of apparatus.

Reliability or readiness to serve is of primary importance and this factor should include the ability of the machine to operate over a long period of years without gradual deterioration or change in performance, which is equivalent to a change in actual capacity. Machines of this type consist of a single revolving element which is held in position by two, or at most three bearings whose function is simply to hold the weight of the rotor against gravity, there being no other contact elements.

Economy

Economy broadly construed should include not only the cost of operation in power consumption of the unit itself and saving in maintenance, lubricant and attendance, but the direct, very large possibilities for saving fuel, decreased oxidation and melting losses should receive due consideration in analyzing the economic advantages of the centrifugal compressor.

The general principles of cupola design are so thoroughly understood and the details of their handling vary so widely in different foundries, that it will not serve the purpose of this paper to touch upon this phase of the subject further than is necessary to bring out the salient inherent characteristics of the centrifugal compressor as affecting quality and cost of iron.

Cupola charging is usually governed by considerations of economy in handling the charge, and attention is paid to accuracy of weights. Great care should be taken in the

distribution of the charge with regard to the uniformity of passages through the charge itself so that the gases will be evenly distributed. The charge is weighed with precision and distributed with the object of bringing the fuel and iron into proper relation; the oxygen should be regarded in the light of a definite element of the charge by weight and regulated in its passage through the charge with equal precision both with regard to rate and uniformity of distribution. A single charge usually consists of roughly 1850 pounds of air, 200 pounds of coke and 2000 pounds of iron, that is the air, by

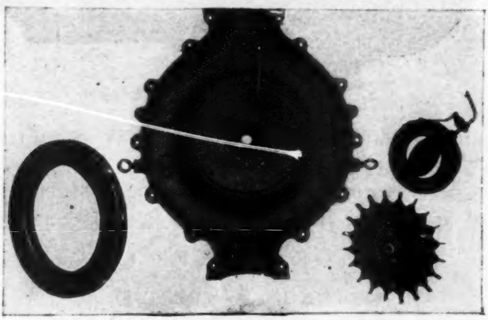


FIG. 1—THE PARTS OF A SINGLE-STAGE CENTRIFUGAL COMPRESSOR

weight, represents approximately 80 per cent of the coke and iron together.

Wind boxes should be so arranged that the temperature of the air does not vary widely at the entrance of the different tuyeres. The oxygen contained in a cubic foot of air varies directly as the absolute temperature, and the passage of oxygen values through tuyeres on opposite sides of the cupola may vary widely, with unequal temperatures resulting in uneven melting conditions. The table of comparative values showing temperature and pressure correction brings this point out clearly.

Air Compression

The theoretical horsepower necessary to compress adiabatically and deliver 100 cubic feet per minute of air at actual initial conditions is shown in Fig. 5.

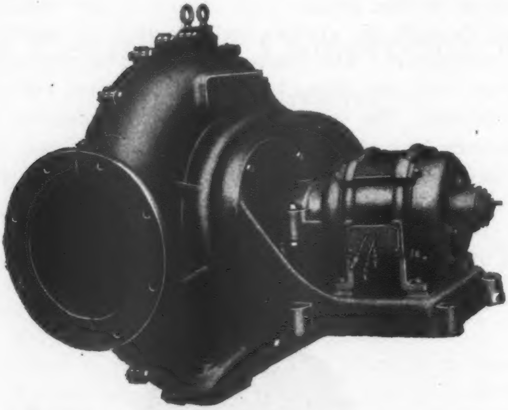


FIG. 2—CENTRIFUGAL COMPRESSOR DRIVEN BY INDUCTION MOTOR

A general formula for compressing 100 cubic feet per minute of any gas of initial pressure, P_0 is as follows:

$$\text{Theo. H. P.} = 0.4364 \frac{K}{K\text{-}1} P_0 \left\{ \left(\frac{P_1}{P_0}\right) \frac{K\text{-}1}{K} - 1 \right\}$$

P_0 = Initial pressure, absolute lbs. per sq. in.
P_1 = Final pressure absolute lbs. per sq. in.

$$K = \text{Ratio of specific heats } \frac{C_p}{C_v} = 1.41 \text{ for air.}$$

$$\text{Theo. H. P. for Air} = 1.501\ P_0 \left\{ \left(\frac{P_1}{P_0}\right) 0.29 - 1 \right\}$$

NOTE:—For pressures below 15 lbs. per sq. in. the following simpler formula holds for any gas:

$$\text{H.P.} = 436\ P_r$$

where P_r = Pressure rise lbs. per sq. in. G.

H.P. = Horsepower to compress and deliver 100 cu. ft. per minute of any gas at initial conditions.

Air Supply

One hundred and fifty cubic feet of air at 60 degrees Fahr. and 14.7 pounds barometer are required, theoretically, to burn 1 pound of pure carbon to CO_2. Coke has a carbon content of 85 to 92 per cent and on account of incomplete combustion about 90 per cent of the air required for complete

combustion is necessary. Therefore in actual practice 120 cubic feet of standard air (60 F.—14.7 bar.) is required per pound of coke. This value varies directly with the absolute temperature and the barometer, and is, therefore, in this latitude subject to very material corrections on account of weather conditions, as will be seen from the following table:

WEIGHT OF AIR IN LBS. PER CU. FT.

Tem. °F.	Absolute Pressure Lbs. Per Sq. In. 13.7	14.7	15.7	16.7
0	.0806	.0864	.0923	.0982
60	.0713	.0764X	.0816	.0868
100	.0662	.0710	.0757	.0805
200	.0560	.0601	.0642	.0683
300	.0486	.0522	.0556	.0592
400	.0430	.0461	.0491	.0522

CUBIC FT. PER LB. OF COKE

Tem. °F.	Absolute Pressure Lbs. Per Sq. In. 13.7	14.7	15.7	16.7
0	109	106	99	94
60	129	120X	113	105
100	139	129	121	114
200	164	153	143	134
300	189	176	165	155
400	204	199	187	171

X Standard.

Air is a mechanical mixture of oxygen and nitrogen. While different authorities give slightly varying proportions of these elements, the following values are generally accepted:

By volume—Oxygen, 20.91 per cent; nitrogen, 79.09 per cent.
By weight—Oxygen, 23.15 per cent; nitrogen, 76.85 per cent.

Air also contains other elements in varying small quantities as water vapor, ozone, carbon dioxide, argon, naon, crypton, etc. The specific heat of air is 0.237.

Combustion

The chemical combination of oxygen with carbon is very rapid; in cupola practice it passes from the tuyere to a point where the temperature is too low for chemical reactions in approximately 1/40 second.

During this brief period all the chemical reactions take place and the initial air in combination with the gases is

expanded to over seven times its original volume at a maximum temperature of approximately 3500 degrees Fahr., which magnifies the effect of any initial instability in the air supply.

Since iron is not an inert metal, it is affected by the rate at which it absorbs heat above the melting point as well as by the chemical reactions, all of which demand for best results not only an exact rate of combustion of the fuel and melting, but a uniform rate, which is absolutely dependent upon a supply of air of correct weight, the uniformity of distribution

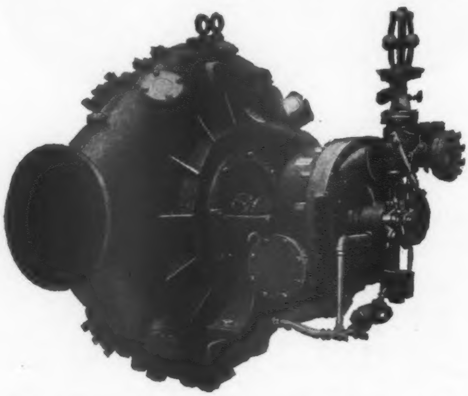


FIG. 3—CENTRIFUGAL COMPRESSOR DRIVEN BY A SINGLE-STAGE CONDENSING CURTIS STEAM TURBINE

in its flow through the charge, and freedom from pulsation effect.

The air requirement may be determined by meter or by observation of the iron. It may be regulated automatically for constant volume as is now standard practice in blast furnace blowing with centrifugal compressors, or it may be hand controlled as is the usual practice in foundries; but in any case a constant, uniform flow of air free from pulsation is necessary. This condition is possible with a centrifugal compressor or direct driven fan.

It is impossible to deliver a perfectly uniform flow of air with a belt-driven fan on account of belt slip, and the very low efficiency of fans operating on pressures of 15 to 16

ounces makes their use for this service inadvisable in many cases.

The pulsating characteristic of air delivered from direct-driven positive pressure blowers makes it difficult to meter such air; and by its nature an air flow delivered in puffs or pulsations does not readily develop a stable uniform rate of combustion.

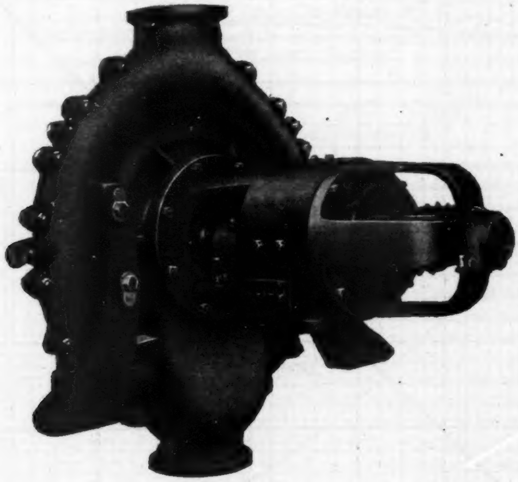


FIG. 4—CENTRIFUGAL COMPRESSOR DRIVEN BY DIRECT CURRENT MOTOR

These two types of blowers are illustrated diagrammatically in Figs. 6 and 7. The power input diagrams indicate that the input to the blower of the positive type is constant regardless of load, whereas the input to the centrifugal compressor is proportionate to the load which effects a large saving in operation.

The centrifugal compressor is an ideal machine for cupola service as it embodies the elements of simplicity, high efficiency, minimum attendance and low upkeep combined with the

inherent characteristics of delivering an air stream of great stability. Without the high inertia due to the high speed of the machine, the perfect smoothness of the air stream could not be obtained.

The centrifugal compressor is a constant-pressure variable-volume machine. It is installed with a blast gate on the intake

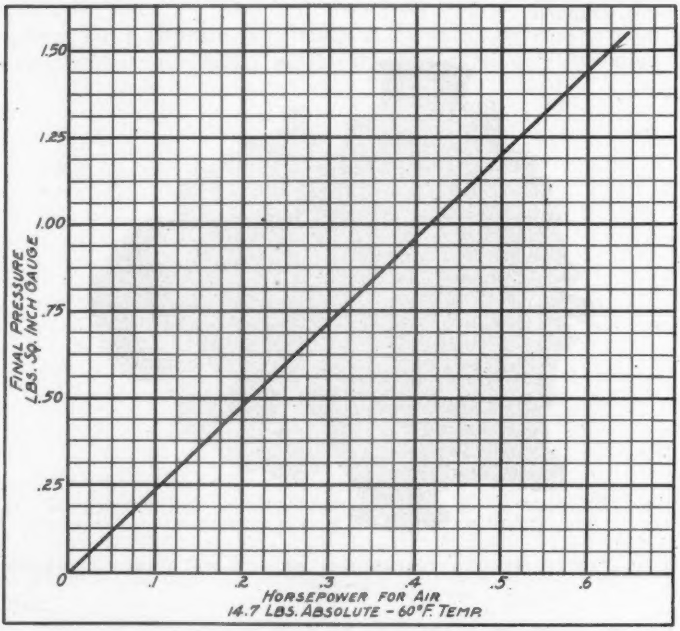


FIG. 5—HORSEPOWER-PRESSURE CURVE

side; a hand control for this gate is usually run to a convenient point at the cupola, so that the volume of air may be conveniently regulated.

A single-stage compressor consists of a casing, a set of guide veins, and impeller of the double inlet type which inherently has no end thrust, thereby eliminating the complication of special thrusts. This impeller is mounted on one end of a single-piece shaft, and the rotor of the motor or steam

turbine is mounted on the opposite end of the shaft. The entire rotating element is supported by two bearings in the smaller capacities and in the larger by three.

The impeller is surrounded by a set of guide veins as illustrated by Fig. 12, and the diagram, Fig. 13. The whole is enclosed by a two-piece casing.

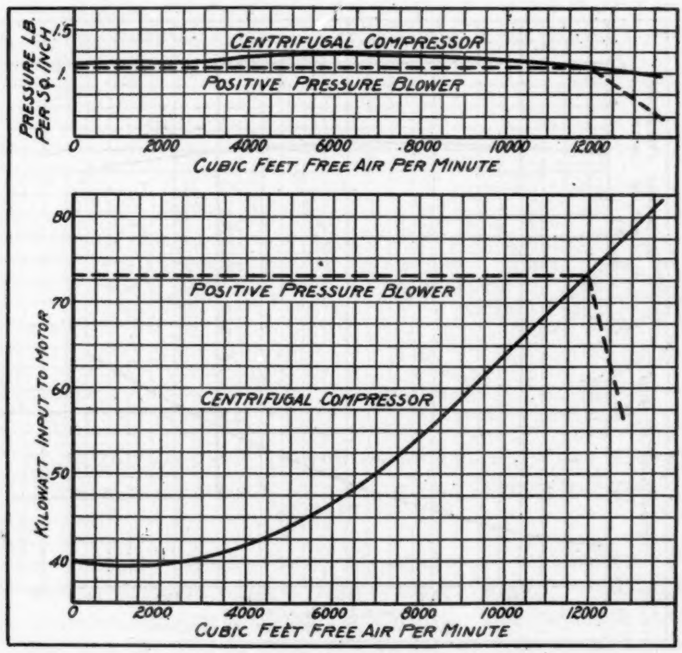


FIG. 6—POWER INPUT AND DELIVERED PRESSURE CURVES FOR A CENTRIFUGAL COMPRESSOR AND FOR A POSITIVE PRESSURE BLOWER

The function of the guide veins is indicated by the curve, Fig. 14, which illustrates the proportion of velocity energy recovered by the centrifugal compressor which is lost entirely in the fan blower. The efficiency of this apparatus is not affected appreciably by large clearances; the capacity rating

is based on actual free inlet air and due to absence of contact parts this rating is retained through the entire life of the machine.

Centrifugal Compressor Design

The general principles of centrifugal compressor design cannot be more clearly brought out than by quoting the

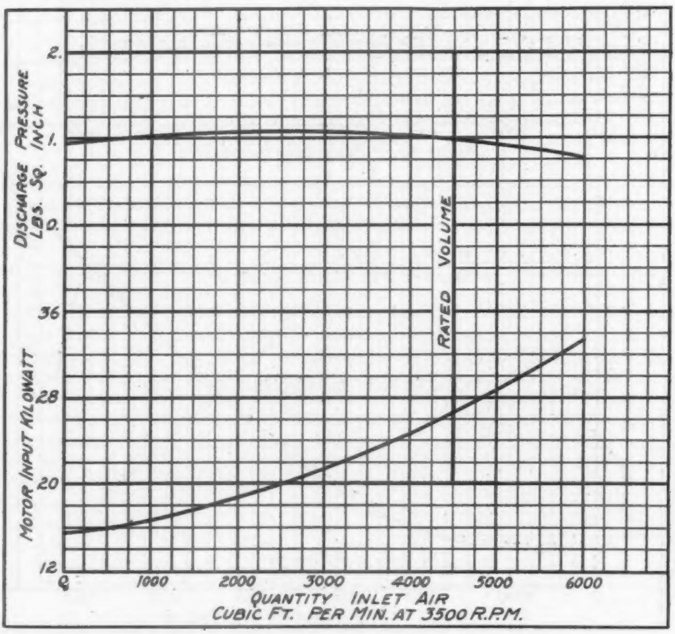


FIG. 7—QUANTITY CURVES—PRESSURE AND POWER AT ATMOSPHERIC TEMPERATURE

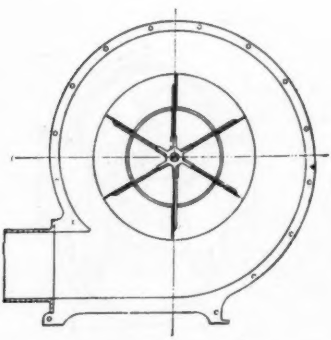
following extract from an article by Dr. L. C. Loewenstein which was published in the *General Electric Review:*

Fig. 13 represents diagrammatically a centrifugal compressor. The air particles enter the impeller at a diameter D_e and leave it at a greater diameter D_a. The impeller is rotated by a motor at an angular velocity ω; the air particles are

thrown outward by centrifugal force and thus exert a pressure which can be expressed by the equation

$$\frac{\left(\frac{D_a}{2}\right)^2 - \left(\frac{D_e}{2}\right)^2}{2g}\,\omega^2 = \frac{u_a^2 - u_e^2}{2g} = \frac{p}{\rho} \quad (1)$$

in which u_a and u_e, Fig. 14, represent the peripheral velocities at the diameters D_a and D_e respectively; p the pressure rise; and ρ the density of the air.



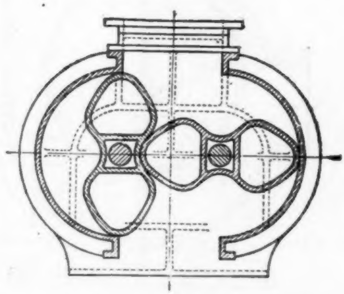


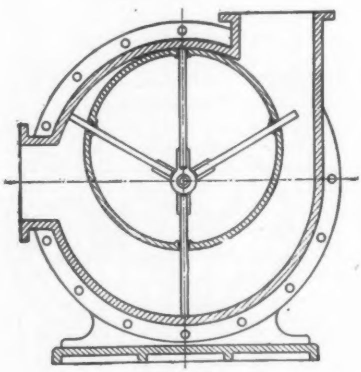
FIG. 8—DIAGRAMMATIC SECTION OF AN ORDINARY FAN BLOWER

FIG. 9—DIAGRAMMATIC SECTION OF ONE TYPE OF POSITIVE PRESSURE BLOWER

The air particles enter the impeller at the diameter D_e with a relative velocity v_e, and leave the impeller at the outer diameter D_a with a relative velocity v_a. The resultant absolute exit velocity w_a of u_a and v_a can be represented by the diagonal of a parallelogram where sides are u_a and v_a. This parallelogram is called the exit velocity diagram. In this diagram u_a and v_a form an angle β_a, which is called the exit angle of the impeller. The angle δ_a, formed by u_a and w_a, is the angle at which the air leaves the impeller, and in order that the air may enter the discharge vanes without shock, their entrance angle must also be δ_a. The object of the discharge vanes is to reduce gradually, with minimum shock losses, the

absolute velocity w_a, and thus transform as much as possible of the velocity head $\frac{w_a^2}{2g}$ into pressure.

The entrance velocity diagram of the impeller must be drawn in a manner similar to that of the exit velocity diagram, that is, so that v_e forms the diagonal of a parallelogram whose sides are u_e and w_e. The entrance angle of the impeller will be designated by β_e and the angle between u_e and



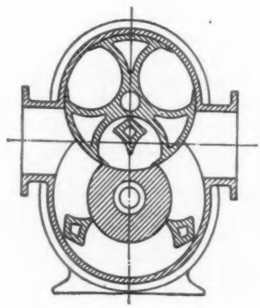


FIG. 10—POSITIVE PRESSURE BLOWER

FIG. 11—POSITIVE PRESSURE BLOWER

w_e by δ_e. The entrance and exit velocity diagrams are shown in Fig. 14.

From the velocity diagrams it will be noted that the air enters the impeller in a radial direction. If the air is not to enter the impeller radially some sort of guide vanes should be provided to properly direct the air; but if the air is to enter radially, only radial ribs are provided to prevent churning of the air before entrance to the impeller. In high speed impellers the blades of the impellers are radial at exit. If they are not radial, great care must be exercised in designing them so that the ensuing centrifugal forces exerted on the blades do not bend or break them. For an impeller with air entering

radially the following relation exists between the various velocities:

$$v_e^2 = u_e^2 + w_e^2 \tag{2}$$

and with impeller blades radial at exit the relation between the various velocities at exit is

$$w_a^2 = u_a^2 + v_a^2 \tag{3}$$

Hence the air leaves the impeller with an absolute velocity w_a

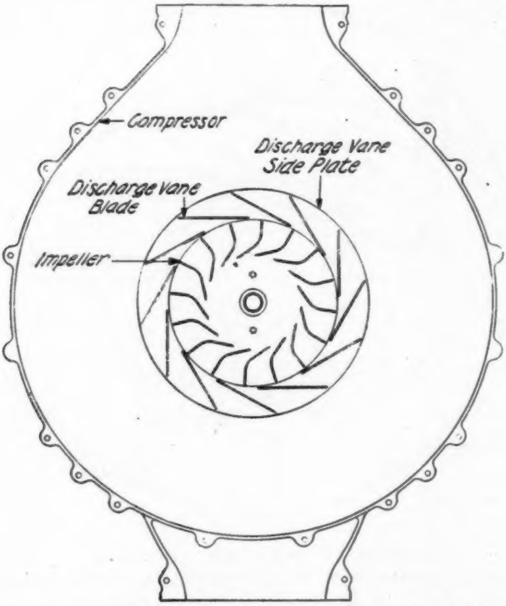


FIG. 12—A DIAGRAMMATIC SECTION OF A SINGLE-STAGE CENTRIFUGAL COMPRESSOR

which is somewhat higher than the peripheral velocity of the wheel.

The pressure rise in the impeller alone can be expressed in terms of the impeller and air velocities at exit by the following equation:

$$\frac{u_a^2 - v_a^2}{2g} = \frac{p}{\rho} \tag{4}$$

in which p is the pressure rise above inlet pressure in pounds

per square foot, and ρ is the density of the air in pounds per cubic foot, provided the speeds u_a and v_a are expressed in feet per second.

When there is no flow of air through the impeller, as is the case when the intake to or discharge from the compressor

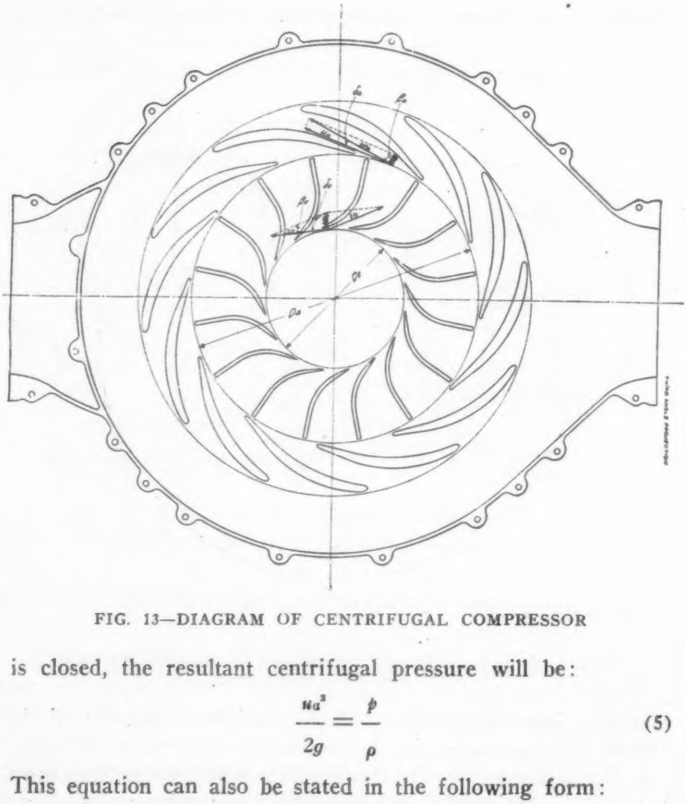


FIG. 13—DIAGRAM OF CENTRIFUGAL COMPRESSOR

is closed, the resultant centrifugal pressure will be:

$$\frac{u_a^2}{2g} = \frac{p}{\rho} \tag{5}$$

This equation can also be stated in the following form:

$$\frac{u_a^2}{2g} = h \tag{6}$$

in which h is the height in feet of a column of the fluid sustained by the impeller. In other words, the centrifugal force

generated will support a column of fluid of height h against gravity.

The discharge vanes receive the air with a velocity of w_a. This high velocity is gradually converted into pressure, provided the vanes are properly shaped. The velocity at the exit end of the discharge vanes is usually very low and if negligible

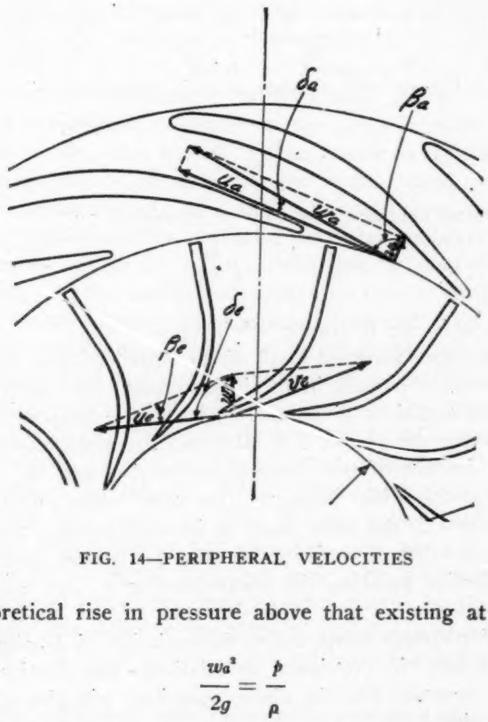


FIG. 14—PERIPHERAL VELOCITIES

the theoretical rise in pressure above that existing at impeller exit is

$$\frac{w_a^2}{2g} = \frac{p}{\rho} \qquad (7)$$

Hence the total theoretical pressure rise obtainable with an impeller having radial blades at exit, and with proper discharge vanes, is the sum of the pressure rise in the impeller,

$$\frac{u_a^2 - v_a^2}{2g}$$

and the pressure rise due to conversion of the absolute velocity at impeller exit $\frac{w_a^2}{2g}$. But as

$$\frac{w_a^2}{2g} = \frac{u_a^2 + v_a^2}{2g} \tag{3}$$

then

$$\frac{u_a^2 - v_a^2}{2g} + \frac{u_a^2 + v_a^2}{2g} = \frac{u_a^2}{g} \tag{8}$$

The total theoretical pressure rise is therefore given by the equation

$$\frac{p}{\rho} = \frac{u_a^2}{g} \tag{9}$$

The actual pressure rise can be expressed by

$$\frac{p}{\rho} = \eta \frac{u_a^2}{g} \tag{10}$$

in which η is the hydraulic efficiency.

It has been assumed in all of the equations that the density ρ is constant. Actually in an air compressor the density varies; but all the equations given are correct for a compressible fluid, provided that the symbol p is taken for the mean effective pressure rise instead of the actual pressure rise, and the density ρ is taken as the initial density. The term "mean effective pressure" is used in the same sense as in reciprocating compressors and it is possible to construct a table giving the values of the mean effective pressure rise corresponding to any actual pressure rise.

In single-stage compressors the variation of density is small and therefore for ordinary calculations the density can be taken as constant and the above equations will give the actual pressure rise.

Micro-Metallography for the Foundry

By Robert J. Anderson, Cleveland

The object of this paper is to call attention to the possibilities for important advances in the application of the metallographic microscope as a means of testing and controlling the products of our foundries. As is usually the case with all important developments, scepticism has prevailed, and mistakes have been made; and it may not be overdrawing the history of metallography to remark that the most absurd predictions have been advanced as to what the microscope could accomplish, which have done much to confound the metal industries. Many difficulties have had to be overcome, but as knowledge has progressed, and the number of applications have increased, the causes of trouble have gradually been eliminated. To set forth a complete treatise on the scope of metallography and its application to the steel and iron foundry business would be a task of considerable magnitude, mainly because of the large mass of material which has been published in the metallographic field, and secondarily because of the inherent difficulty of a logical presentation of the subject. Rapid strides have been witnessed in the past few years, so that at the present writing the methods of metallography find extensive application as a means of control in the metal industries and even in foreign fields. The knowledge which has come to hand relative to the relation which grain size bears to the physical properties of metals and their alloys has given rise to a new method of scientific regulation.

Thirty years ago, metallography as a science was virtually unknown, and it is only within the last 15 to 20 years that it has received serious consideration by manufacturers and consumers as a valuable means of metal testing. The development of the science in the early years of its history was slow, but the advances in the past five years have probably exceeded all those previously made. At present metallography is taught in

almost all technical and engineering institutions of university grade, and the methods of metallographic testing find wide use in iron and steel and in non-ferrous metallurgy.

Metals and alloys owe their industrial importance, in large degree, to their physical properties, and it is in the testing and determination of these physical properties that the methods of metallography have come to be indispensable. The physical properties of metallic alloys are dependent upon their proximate structural compositions rather than upon their ultimate chemical compositions, and in revealing the former metallography demonstrates its value. The chemical analysis furnishes information which is highly desirable, but it cannot make possible much knowledge concerning the structure and physical constitution of substances. It will be recalled by most people interested in iron and steel, that the chemical laboratory experienced difficulty in the early days in finding a place in the works; metallography has gone through the same trying stage in its short existence. That it has demonstrated its true worth is proved beyond doubt by the large number of manufacturing concerns that have installed laboratories and by the service it has rendered.

Why Foundries Have Been Slow

It appears that the foundry interests have not taken to metallography with the interest which the science deserves, and there is unquestionably sufficient reason for this condition. In the first place, the foundry interests are, broadly speaking, considerably diversified, and their tonnage per unit is smaller than in the case of steel works, so that the installation of a laboratory and the employment of a metallurgist would not appear warranted from the standpoint of first cost. Secondly, it seems that in comparison to certain other industries fewer men highly trained in science have entered the foundry field. The reason for the latter condition is not exactly apparent because the opportunities are large. Only a small percentage of the foundries in this country employ metallographic methods, so that the field would appear to be practically virgin. Therefore, by deduction from what metallography has accomplished in other fields, the writer has every reason to believe that a consistent and intelligent application of this science will

improve the product of the foundries in a measure out of all proportion to the amount of endeavor.

There is no attempt in this paper to explain the methods of metallography. As regards foundry applications, the subject has been dealt with at length by others[1]. Several text books on the subject have appeared in the past few years, and we now have "Metallography", by Cecil H. Desch; "The Metallography and Heat Treatment of Iron and Steel", by Albert Sauveur, in which the practical aspect is well cared for; "The Metallography of Steel and Cast Iron", by H. M. Howe;

FIG. 1—GRAY CAST IRON, UNETCHED, X100 (AFTER G. S. EVANS)

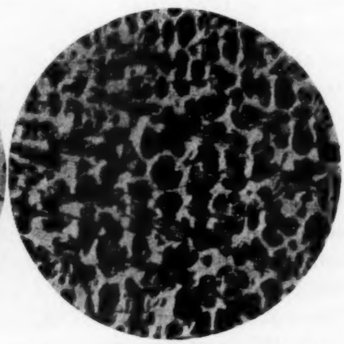


FIG. 2—WHITE CAST IRON, ETCHED, X100 (AFTER O. W. STOREY)

"Metallic Alloys", by G. H. Gulliver; "Physical Metallurgy", by Walter Rosenhain, a lucid exposition; and "Metallographie", by W. M. Guertler. The *Journal* of the Iron and Steel Institute, London, devotes considerable space to the ferrous field; the *Journal* of the Institute of Metals, London, covers the non-ferrous field; and the *Internationale Zeitschrift für Metallographie* covers both ferrous and non-ferrous metallography. Wm. Campbell recently summarized the late progress in metallography.[2]

[1]Sauveur, A., Metallography Applied to Foundry Work, *Iron and Steel Mag.*, vol. IX, 1905, p. 547; and vol. X, 1905, pp. 29, 309 and 413.

Primrose, H. S., Metallography as an Aid to the Brass-Founder, *Journ. Inst. of Metals*, vol. IV, No. 2, 1910, p. 248 *et seq.*

[2]Campbell, Wm., Recent Progress in Metallography, paper at the Cleveland meeting, 1916, American Institute of Metals.

The available literature on the metallography of cast iron is indeed meagre, so that it may not be out of place here to recall a small portion of the present knowledge. The paucity of literature is one criterion from which we may deduce that no great deal of scientific work has been accomplished, at least not in any measure comparable with what has been performed upon both carbon and alloy steels. It appears to be an idle ceremony to discuss in this place the phenomena which occur when alloys of varying carbon content pass from the liquid condition to room temperature. These phenomena are readily secured from a consideration of the now well-known carbon-iron diagram. It suffices to state that our knowledge of the transformations in steels and cast irons is based upon this diagram, as are all methods for heat treatment.

Macrostructure.—For a proper understanding of the structure of cast irons, or other metallic alloys, it is of prime importance to observe the macrostructure or structure as it appears to the naked eye. This is equivalent in practice to the examination of fractures of broken castings. Sudden breakages are indicated, in general, by a granular appearance, while fractures which have resulted from repeated stresses will be smoother. Macroscopic examination may show, in a failed part, at what point the fracture initiated, due to local defects. In the event that local defects are not found or in case microscopic examination is desirable, micro-sections should be secured. Macroscopic examination may readily distinguish between various types of irons by simple inspection of the fracture, but it is not to be relied upon as absolute.

Microstructure.—Knowing the constitution and heat treatment of any given iron, we can predict with certainty what its structure will be. In general, its structure will be dependent upon the percentage of carbon present, upon the condition of the carbon, and therefore upon its chemical composition or heat treatment, or both. The carbon present in cast iron may be in three different forms: First, entirely in the combined form, as cementite; second, entirely in the uncombined form, as graphite; and third, partly combined and partly uncombined. These three occurrences are considered in the following paragraphs, but first it may be well to consider the formation of

combined and graphitic carbon. When cast iron freezes, the carbon remains in the combined form as Fe_3C, but this is an unstable compound, so that the reaction

$$Fe_3C = 3Fe + C$$

is always striving to occur[3]. Two factors are particularly cogent ones in promoting the formation of graphite: First, slow cooling during and below the freezing range; and second, the presence of silicon. The conditions most favorable to the production of combined carbon are: First, fast cooling during

FIG. 3 — STRUCTURE RESULTING FROM ANNEALING AT TOO LOW A TEMPERATURE, BUT SLOWLY COOLED, X100 (AFTER O. W. STOREY)

and below the freezing range; and second, high manganese or sulphur.

Gray Irons.—Irons totally free from combined carbon are rare, the usual so-called gray irons having at least some part of their carbon in the combined form as Fe_3C. However, to consider an iron whose entire carbon content is in the graphitic condition, we deduce at once that only two metallographic constituents can be present, graphite and ferrite. A commercial gray iron as observed under the microscope is shown in Fig. 1. The graphite appears as long curved plates embedded in the soft ferrite matrix. These plates so effectively destroy

[3]According to the phase rule, the system ferrite-cementite is in metastable equilibrium, while the ferrite-graphite system is the one in stable equilibrium.

the continuity of the ferrite, that the ductility of the iron is removed. Where graphite occurs in small rounded particles as in malleable cast iron, the matrix exhibits the normal ductility and malleability of ferrite. Commercial irons, as already stated, normally contain some combined carbon, those with less than 3 per cent nearly always having some combined carbon.

White Irons.—White cast iron is cast iron containing carbon only in its combined form and consequently free from graphite. Macroscopically, its fracture is white and metallic in appearance. The conditions already enumerated as being favorable to the production of gray iron must be absent, so that white irons are dependent for their occurrence upon either one or a combination of the following: First, rapid cooling during and below the freezing range; and second, high sulphur or manganese. Indeed an iron may be white even with high silicon and low manganese and sulphur in case the freezing is sufficiently rapid, or it may be white even with slow freezing if the sulphur and manganese are sufficiently high and the silicon low enough. Microscopically, a slowly cooled white iron will consist of pearlite and cementite. Such an iron is illustrated in Fig. 2; the white areas are cementite, while the dark ones are pearlite not resolved at the magnification employed. White cast iron is non-malleable and very hard and brittle. These qualities are due to the large amount of free cementite present, this constituent itself being hard and brittle.

Mottled Irons.—In the majority of commercial irons, as already stated, the castings usually contain both combined carbon and graphite, usually from 0.25 to 1.50 per cent combined carbon and the remainder graphite. Where irons are partly gray and partly white in appearance, they are called mottled irons.

Malleable Iron.—The subject of malleable iron has been dealt with by Dr. Moldenke[4], and by Leasman[5] and Storey[6], and others before this association. Malleable iron has not received its full quota of scientific attention, if published data can be

[4]Moldenke, Richard, "The Production of Malleable Castings."

[5]Leasman, E. L., "A Study of the Annealing Process for Malleable Castings," *Trans. A. F. A.*, vol. XXII, 1913, p. 169 *et seq.*

[6]Storey, O. W., "Researches in the Annealing Process for Malleable Castings," *Trans. A. F. A.*, vol. XXIII, 1914, p. 461 *et seq.*

any criterion. A great deal more is no doubt known, to a few, concerning the process of malleablizing than the altogether sparse literature would indicate, because of the secrecy which is supposed to and actually does overhang the process. Malleable castings are cast initially as hard white cast iron and are rendered somewhat malleable by, in part, graphitizing the cementite and converting the carbon into small rounded particles, and in part by burning out some of the carbon by the oxygen of the packing materials. In view of what has gone before it appears useless to dwell on the subject at greater length unless it be to point out how the metallographic microscope has served as an efficient tool in some of the researches made in this process. Photomicrographs by Storey show the influence of packing materials, temperature of annealing, and time of annealing in the malleablizing process. In Fig. 2 is seen a normal white iron where the carbon is all present in the combined state; the white areas represent cementite while the dark areas are pearlite. Data obtained from Storey's researches show that when malleable is annealed for too short a time or at too low a temperature and slowly cooled, the structure consists under the microscope of ferrite and cementite and temper carbon, as shown in Fig. 3. Too rapid cooling after correct annealing results in a structure of temper carbon enclosed by ferrite, the latter being in turn enclosed by pearlite, as in Fig. 4. Proper annealing results in the structure shown in Fig. 5, consisting of ferrite and temper carbon.

Methods and Apparatus

Selection.—In selecting microsections for examination under the microscope, it is usually not important to select the position in a casting from which the piece is taken, unless it is to observe local conditions. In the case of failure of metal in service, it is necessary that the sections should be taken from a position close to the fracture, as in many instances the casting may be sound with the exception of the part which failed locally. Stead[7] remarked on this matter as follows: "The importance of this is not always recognized, and speci-

[7]Stead, J. E., "Micro-Metallography and its Practical Application," *Journ. West of Scot. Iron and Steel Inst.*, vol. XIX, No. 4, Jan., 1912, p. 171.

mens taken from positions far removed from the seat of failure are occasionally sent to the expert for examination and report as to the cause of failure—a proceeding which is equivalent to asking a medical practitioner to examine one's perfectly sound toe with the expectation that he will be able to tell why there is tumor on his neck."

Grinding and Polishing.—The use of motor-driven apparatus for these operations is to be recommended in preference to hand work, as the latter is tedious. Where a large number

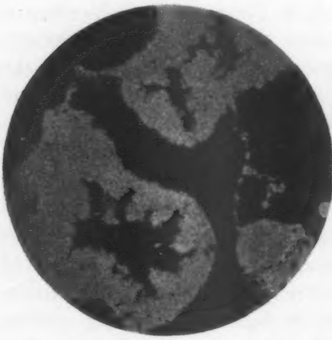


FIG. 4 — TEMPER CARBON SURROUNDED BY FERRITE IN TURN ENVELOPED BY PEARLITE, X100 (AFTER O. W. STOREY)

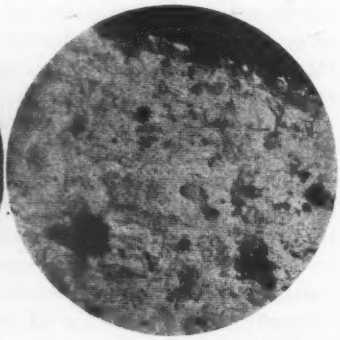


FIG. 5 — MALLEABLE CASTING SHOWING CARBONLESS RIM, X100 (AFTER O. W. STOREY)

of microsections are to be prepared, as in routine work, power polishing is eminently more suitable.

Etching and Etching Reagents.—For the detection of slag inclusions, porosity, oxides, sulphides, etc., the sections may be examined unetched. For the determination of the constituents and for distinguishing between occluded substances, it is necessary to etch. The sections are treated with reagents which have been found to be most suitable, or they may be heat tinted until the constituents assume differential oxidation films. The reagents in common use have been described in the literature of metallography, as has been the heat-tinting method of Stead.

Apparatus.—Any compound microscope fitted with an illuminator for opaque objects will serve for examinations, but it will be found best to obtain a metallographic microscope such as is supplied by various makers. An eminently satisfactory instrument[8] is shown in Fig. 6. The methods of examining and the apparatus required for photography have been described at length elsewhere and need not be dealt with in this paper.

Impurities in Iron

As is well known, the common impurities in cast iron, as in steels, are the elements sulphur, manganese, silicon and phosphorus. Since all cast iron which is not refined in steel-making processes is used for making iron castings, the impurities present in the pig iron will be present in the iron castings, and the fundamental characteristics of those castings are direct functions of the percentages of the different impurities present. Carbon, either combined or graphitic, or both, is of course a constituent of all iron castings. The impurities mentioned exert a dual influence; first, upon the iron itself; and second, upon the carbon.

Sulphur.—Sulphur in increasing percentages increases the amount of combined carbon present in any given iron, and when present as FeS this effect is greater than when in the form of Mns[9]. Having observed the fracture of an iron, the methods of metallography are valuable in supplementing the macroscopic observation. To employ these methods for the approximate determination of sulphur in cast iron, the following procedure is adopted: A piece of iron is polished and pressed firmly upon a piece of photographic silver bromide paper, which has been immersed in dilute sulphuric acid; the contact of the iron and the paper is maintained for a given length of time, and the amount of brown stain of silver sulphide formed is an indication of the percentage of sulphur present. This method has found considerable application in many steel works to determine segregation of sulphur in steel. The method has not found any wide use in the foundry, but there is no reason why it should not be useful there also.

[8]After the Bausch and Lomb Co., Rochester, N. Y., from the design of Prof. Sauveur.

[9]Stoughton, B., The Metallurgy of Iron and Steel, New York, 1911, p. 325.

Manganese.—The effect of this element is to increase the combined carbon in an iron, but its influence is not as potent as that of sulphur. Also, it should be stated that since considerable of the manganese is in the form of MnS, it does not exert the effect of manganese in the elemental condition. Manganese robs FeS of its sulphur, so that the ultimate effect of manganese is to decrease the percentage of combined carbon present in the iron. Any manganese in excess of the amount required to form MnS is in the form of the manganiferous cementite, $(FeMn)_3C$, and consequently increases the amount of combined carbon. This effect of manganese is therefore apparently contradictory.

Phosphorus.—This element also exerts an apparent contradictory effect upon irons in that it tends to increase the percentage of combined carbon, but it also has the effect of lengthening the period of time of the mushy stage, *i. e.*, the range between the *liquidus* and *solidus.* This increased period of time promotes the graphitization of cementite. Micrographically, the occurrence of the reaction, $Fe_3C = 3Fe + C$, can be recognized by the contiguity of the graphite and ferrite which are products of the reaction. Graphitization is promoted by the presence of silicon and occurs with greater rapidity at high rather than low temperatures. The phosphorus, by increasing the length of the mushy stage, consequently favors graphitization, and the combined carbon will therefore be lower. With low silicon and high phosphorus, the tendency for combined carbon to increase is strong; when silicon is high, the tendency is towards graphitization; when the phosphorus is high, chemically it has the effect of retaining carbon in the combined state, regardless of the length of the mushy range. Phosphorus may then tend to keep the carbon in the combined form if other chemical influences, *e. g.*, silicon, are not potent; it may make the precipitation of graphite more readily if the physical conditions are such that the graphite is bound to precipitate.

The Mushy Stage

A word on the mushy stage may not be out of place: It exists, as already indicated, in the range of temperature between the *liquidus* and *solidus.* During this period, the cooling metal

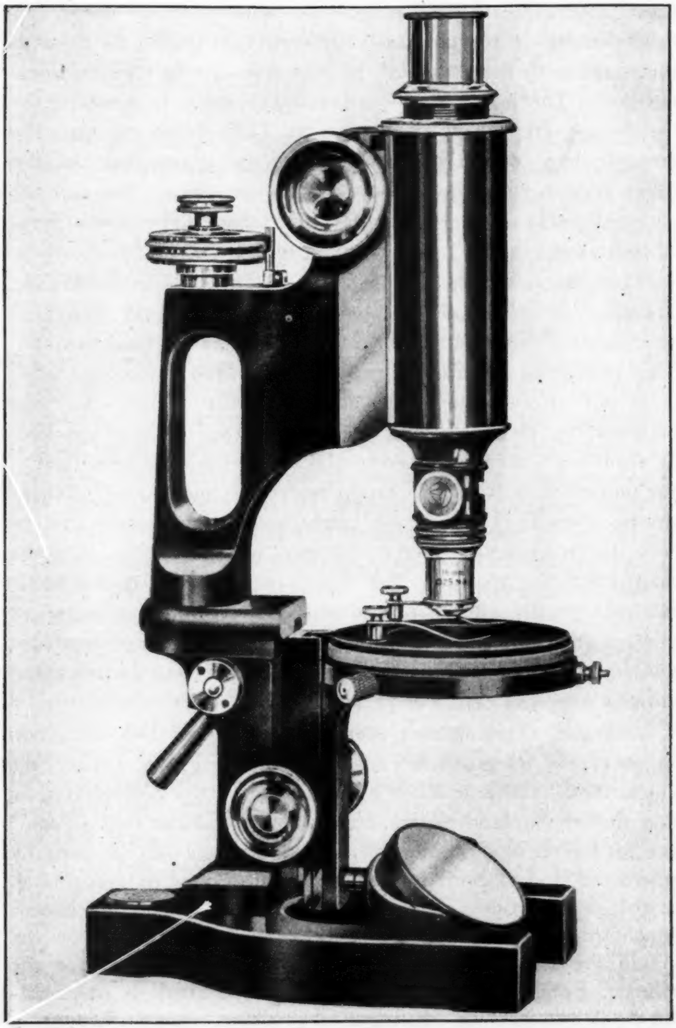


FIG. 6—METALLURGICAL MICROSCOPE, APPROXIMATELY HALF SIZE

consists of a mechanical mixture of molten mother metal and solid particles of primary austenite. All cast irons pass through this stage with the exception of that iron having eutectic composition. The lower limit of the mushy range is constant for cast irons, free from impurities, at 1135 degrees Cent., the freezing temperature of the eutectic; the upper limit of the range varies with the carbon content on either side of the eutectic composition. Impurities may change the lower limit of the range.

In gray iron, that is one where extensive graphitization has gone on, almost all the phosphorus is present as phosphide of iron, Fe_3P, segregated in isolated masses throughout the iron. The phosphide of iron is readily recognized microscopically; it is not affected by dilute acids, but the metallic portions between the phosphide and the graphite are readily attacked. If then a polished micro-section be etched with dilute HNO_3, the phosphide will be seen bright under the microscope. Where the phosphorus is high, these bright spots of phosphide can be seen macroscopically, but when the phosphorus is low the microscope is required for their detection. Metallographic methods readily offer a procedure for determining whether an iron is high or low in phosphorus. However, microscopic analysis must be regarded as only approximate and cannot entirely supplant chemical analysis.

Silicon.—This element promotes the precipitation of carbon in the form of graphite; an iron containing say 3 per cent silicon will have practically no cementite, if the cooling is slow and the sulphur and manganese low. With 3 per cent silicon[10], the formation of austenite during solidification may be partially prevented, and graphite instead of cementite may be precipitated at 690 degrees Cent. Silicon is therefore an important element in control of foundry products because of its effect upon the condition of the carbon. Silicon probably forms with iron the silicide, FeSi, which is soluble in ferrite. There is no metallographic method of distinguishing silicon unless through a rough approximation arrived at from the graphite present. It is

[10]Stoughton, B., The Metallurgy of Iron and Steel, New York, 1911, p. 324.

stated[11], however, that under similar conditions the greater the percentage of silicon present in ferrite, the slower the etching of that constituent.

Conclusion

As has already been stated, it appears to be most singular that metallography has not yet rendered the quota of results to the foundry business which it is capable of, considered in the light of its immense value to steel manufacture. Originally, when the microscope was introduced as an aid in the control of steel products, it was held by some people that it would be able to detect everything that the chemical analysis failed to give. Patently, such claims have never been realized. Most of the metals and many of their alloys have been studied by means of the microscope, but a more complete knowledge is still desired. I do not think that anyone questions the value of the chemical laboratory as a method of control in metallurgical operations; still, the metallographic laboratory can render greater service when the results of its procedure are properly interpreted. Microscopic examination when conducted by experts can more speedily explain the properties of both metals and alloys than can chemical analyses. The two, however, should be regarded as supplemental.

After reviewing everything, both for and against, the writer strongly affirms his belief in metallography as indispensable in metal manufacturing and fabricating processes, and that the foundry interests may profitably install apparatus to that end. Instances may be cited almost without end to justify the claim that appropriately guided scientific investigation pays—that it is a business asset. The time has arrived when all prejudices should be cast away, and when this method is appreciated more widely it will be recognized more widely as one of the most important advances in modern metallurgy.

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[11]Sauveur, A., The Metallography and Heat Treatment of Iron and Steel, Cambridge, Mass., 1916, p. 386.

The Registered Attendance

The following members registered their attendance at the annual meeting of the American Foundrymen's Association, Inc., held at Boston, Mass., Sept. 24-28, 1917:

ABBE, A. N., purchasing agent, American Hardware Corp., New Britain, Conn.
ABORN, G. P., manager, Blake & Knowles Steam Pump Works, East Cambridge, Mass.
ADAMS, C. E., superintendent, York Foundry & Machine Co., York, Pa.
ADAMS, I. D., salesman, Federal Foundry Supply Co., Cleveland.
ADAMSON, ROBERT, superintendent, Farrell Foundry & Machine Co., Ansonia, Conn.
AHRENS, J. F., New England representative, *The Iron Trade Review*, New York.
ALEXANDER, D., assistant manager of sales, Mumford Molding Machine Co., Chicago.
ALEXANDER, J. D., salesman, Sand Mixing Machine Co., New York.
ALEXANDER, M. W., General Electric Co., West Lynn, Mass.
ALLEN, C. G., superintendent, Chas. G. Allen Co., Barre, Mass.
ALLING, EDWARD B., New Britain, Conn.
ALTEN, G. H., Alten's Foundry & Machine Co., Lancaster, O.
AMAN, J. H., president, Monarch Foundry Co., Detroit.
ANDERSON, E. B., assistant superintendent, T. H. Symington Co., Rochester, N. Y.
ANDERSON, J., foundry superintendent, S. L. Moore & Sons Corp., Elizabeth, N. J.
ANDERSON, NILS, president, Debevoise-Anderson Co., New York.
ANDRESELL, A. C., assistant sales manager, Chicago Pneumatic Tool Co., Chicago.
ANGENBRAUN, P. F., superintendent, Yale & Towne Mfg. Co., Stamford, Conn.
ANTHONY, L. J., foreman, Weir Stove Co., Taunton, Mass.
ANTISELL, F. L., Raritan Copper Works, Perth Amboy, N. J.
ARNOLD, H. L., secretary-treasurer, Terre Haute Malleable & Mfg. Co., Terre Haute, Ind.
ASHCRAFT, A. E., general superintendent, E. & T. Fairbanks & Co., St Johnsbury, Vt.
ATWATER, H. R., vice president, Osborn Mfg. Co., Cleveland.
AYERS, E. M., president, Interstate Sand Co., Zanesville, O.

BABBITT, J. D., foundry superintendent, Jos. Reid Gas Engine Co., Oil City, Pa.
BABBITT, R. M., superintendent, pattern department, Kalamazoo Stove Co., Kalamazoo, Mich.
BACKERT, A. O., vice president, Penton Publishing Co., Cleveland.

BACON, C. C., secretary, Ross Tacony Crucible Co., Philadelphia.
BAILEY, E. C., president, Milford Iron Foundry, Milford, Mass.
BAIRD, W. E. manager, foundry department, American Gum Products Co., New York.
BAKER, H. H., secretary, Sterling Wheelbarrow Co., West Allis, Wis.
BALDWIN, R. L., electric furnace representative, United States Steel Corp., New York.
BALZER, E. H., foreman pattern department, Avery Co., Peoria, Ill.
BANBURY, F. H., sales engineer, Birmingham Iron Foundry, Derby, Conn.
BANNON, WILLIAM, machinist, Dodge Mfg. Co., Ltd., Toronto, Ont.
BARNES, A. J., advertising manager, Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.
BARRINGER, J. M., assistant manager, Timken-Detroit Axle Co., Canton, O.
BARTON, C. V., superintendent, Martin Mfg. Co., Whitley, Ont.
BATES, RICHARD, American Car & Foundry Co., Berwick, Pa.
BATTEN, G. C., foundry foreman, Lunkenheimer Co., Cincinnati.
BATTEN, W. A., eastern sales manager, Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.
BAUER, C. S., advertising manager, *The Iron Age*, New York.
BAUER, F. W., Rogers, Brown & Co., Cincinnati.
BAXTER, D. D., salesman, E. J. Woodison Co., Detroit.
BAYER, JOHN, salesman, Federal Foundry Supply Co., Cleveland.
BEAN, W. R., research department, Eastern Malleable Iron Co., Naugatuck, Conn.
BEATTY, W. G., general manager, Beatty Bros., Ltd., Fergus, Ont.
BEAVER, A. B., chemist, National Cash Register Co., Dayton, O.
BECK, H. E., manager, Dennison Foundry & Machine Co., Dennison, O.
BECK, S. J., foreman, Pusey & Jones Co., Wilmington, Del.
BEEBE, E. P., assistant treasurer, *The Iron Age*, New York.
BELL, DANIEL, foundry foreman, Dominion Coal Co., Ltd., Glace Bay, N. S.
BELL, DONALD, Dominion Coal Co., Ltd., Glace Bay, N. S.
BELL, HENRY, foundry superintendent, Dodge Mfg. Co., Mishawaka, Ind.
BELL, R. S., foundry foreman, New Jersey Zinc Co., Palmerton, Pa.
BELLAYNTO, H. E., New England Butt Co., Providence, R. I.
BENNETT, T. B., superintendent, Maxwells, Ltd., St. Marys, Ont.
BENNETT, WM., superintendent, Union Steel Castings Co., Pittsburgh.
BERGER, C. L., vice president, Eastern Malleable Iron Co., Naugatuck, Conn.
BERGSTROM, E., foreman, Birmingham Iron Foundry, Derby, Conn.
BETTENCOURT, H. M., timekeeper, Weir Stove Co., Taunton, Mass.
BILLINGS, C. E., treasurer, New Haven Sand Blast Co., New Haven, Conn.
BILTON, C. E., president, Bilton Machine Tool Co., Bridgeport, Conn.
BIRD, R. C., general manager, Broadway Iron Foundry Co., Cambridge, Mass.
BIRD, W. W., director, Washburn shops, Worcester Polytechnic Institute, Boston.
BIRKENSTEIN, H., manager, H. S. Birkenstein & Sons, Chicago.
BLAUVELT, J. F., agent, New England Butt Co., Providence, R. I.
BLOCH, W. A., president, Spuck Iron & Foundry Co., St. Louis.
BOETTCHER, M. E., foundry foreman, Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
BOOTH, W. A., general superintendent, Universal Winding Co., Providence, R. I.

BORN, H. G., manager, Born Steel Range Co., Cleveland.
BOUGHER, H. M., president, J. W. Paxson Co., Philadelphia.
BOURNE, R. H., vice president, Whiting Foundry Equipment Co., Harvey, Ill.
BOWERS, W. J. superintendent, American Cast Iron Pipe Co., Birmingham, Ala.
BRADLEY, W. P., superintendent of foundries, American Bridge Co., Ambridge, Pa.
BRADY, F. W., mechanical engineer, International Correspondence School, Scranton, Pa.
BRADY, G. A., salesman, E. J. Woodison Co., Detroit.
BRAID, A. F., metallurgical engineer, Goldschmidt Thermit Co., New York.
BRANT, W. J., Pittsburgh, Pa.
BRAUCHER, P. S., foundry manager, P. & R. Railroad, Reading, Pa.
BRAUGHTON, A. S., superintendent, A. L. Swett Iron Works, Medina, N. Y.
BRAUN, W. P. M., president, Pennsylvania Lawn Mower Works, Philadelphia.
BRETT, J. F., assistant superintendent, McNab & Harlin Mfg. Co., Paterson, N. J.
BRIGGS, W. C., sales engineer, Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.
BROUGH, E. N., foundry superintendent, E. & T. Fairbanks Co., St. Johnsbury, Vt.
BROWN, H. B., treasurer, McLagon Foundry Co., New Haven, Conn.
BROWN, J. F., foundry superintendent, Morgan Engineering Co., Alliance, O.
BROWN, L. K., secretary-treasurer, Interstate Sand Co., Zanesville, O.
BROWN, L. S., president, Springfield Facing Co., Springfield, Mass.
BUCH, R. S., president, Buch Foundry Equipment, York, Pa.
BUECHELE, L. F., foundry manager, American Pin Co., Waterbury, Conn.
BUGGERSTAFF, J. W., foundry foreman, American Locomotive Co., Schenectady, N. Y.
BULL, R. A., vice president, Duquesne Steel Foundry Co., Pittsburgh.
BUNTS, NEAL, superintendent, Pulaski Foundry, General Chemical Co., Pulaski City, Va.
BURGESS, W. H., president, International Malleable Iron Co., Guelph, Ont.
BURMAN, G. A., manager, E. J. Woodison Co., Detroit.
BURNETT, C. H., assistant manager, Western Foundry Co., Wingham, Ont.
BURTON, J. R., secretary and treasurer, Geneva Foundry & Machine Co., Geneva, Ill.
BUSS, J., foreman, Albany Foundry Co., Albany, N. Y.

CAMP, G. E., secretary, Waterbury Castings Co., Waterbury, Conn.
CANNON, G. W., Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich.
CARLISS, O., salesman, Midland Machine Co., Detroit.
CARMICHEAL, H. J., foundry superintendent, McKinnon Dash Co., St. Catherines, Ont.
CARPENTER, J. B., salesman, Buckeye Products Co., Wilmington, Del.

CARROLL, G. P., foundry foreman, Oil Well Supply Co., Oil City, Pa.
CHADWICK, F. B., sales engineer, Oxweld Acetylene Co., Newark, N. J.
CHAMBERS, WM., salesman, Garden City Sand Co., Chicago.
CHAPMAN, H. W., manager, T. M. Chapman's Sons Co., Old Town, Me.
CHAPPELKA, C. J., assistant superintendent, Chisholm-Moore Mfg. Co., Cleveland.
CHASE, C. M., superintendent, Toronto Hardware Mfg. Co., Toronto, Ont.
CHATFIELD, W. S., foundry superintendent, Kanawha Mfg. Co., Charleston, W. Va.
CHRISTOPHER, A. G., Magee Furnace Co., Taunton, Mass.
CLARK, R. W., salesman, Rogers, Brown & Co., New York.
CLARKE, E. W., superintendent, Eastern Malleable Iron Co., Wilmington, Del.
CLEGHORN, ROBT., foundry superintendent, Sweet & Doyle Foundry & Machine Co., Troy, N. Y.
CLELAND, S. H., eastern manager, Black Products Co., New York.
COFFIN, W. H., salesman, Springfield Facing Co., Springfield, Mass.
COLE, F. V., circulation manager, Penton Publishing Co., Cleveland.
COLEMAN, A. E., superintendent, Anthes Foundry Co., Ltd., Winnipeg, Man.
COLEMAN, J. H., salesman, Tabor Mfg. Co., Philadelphia.
COLLINS, J. W., production manager, Aluminum Castings Co., Detroit.
COLTMAN, J. D., superintendent, Waterbury Castings Co., Waterbury, Conn.
COLVIN, C. T., treasurer, Colvin Foundry Co., Providence, R. I.
CONE, E. F., associate editor, *The Iron Age,* New York.
CONWAY, J. L., superintendent, Fremont Stove Co., Fremont, O.
COOLEY, G. A., salesman, Pangborn Corp., Hagerstown, Md.
CORBIN, A. F., president, Union Mfg. Co., New Britain, Conn.
CORSE, W. M., manager, Titanium Bronze Co., Niagara Falls, N. Y.
COSTLEY, S. R., J. S. McCormick Co., Pittsburgh.
COTTRILL, G. F., vice president, Green's Car Wheel Mfg. Co., St. Louis.
COVEY, H. S., secretary, Cleveland Pneumatic Tool Co., Cleveland.
CROPSEY, P. H., malleable foundry supervisor, General Electric Co., Erie, Pa.
CROSSMAN, J. A., manager, Amherst Foundry Co., Amherst, N. S.
CUNNINGHAM, J. J., manager, Western Foundry Co., Wingham, Ont.
CUNNINGHAM, R. P., superintendent, James Hunter Machine Co., North Adams, Mass.
CURRAN, J. J., metallurgist, Henry Souther Engine Co., Hartford, Conn.
CURTIN, T. I., general manager, Waltham Foundry Co., Waltham, Mass.
CUTHBERT, S. B., foundry superintendent, Carnegie Steel Co., Braddock, Pa.
CULLEN, J., foreman, Walker & Pratt Mfg. Co., Watertown, Mass.

DARKE, J. M., chemist, General Electric Co., Lynn, Mass.
DARRISSE, A., manager, Desjardins Co., St. Andre, Que.
DAVIES, G. C., manager foundry iron department, Pilling & Crane, Philadelphia.
DAVIS, C. E., foundry owner, Rutland, Vt.
DAVIS, T. R., assistant general manager, Eastern Malleable Iron Co., Wilmington, Del.
DAVIS, WM., superintendent, New Castle Foundry Co., New Castle, Ind.
DEAN, W. J., foundry superintendent, Saco-Lowell Shops, Biddeford, Me.

DEBENO, F. E., pattern superintendent, General Electric Co., Erie, Pa.
DECKER, E. S., Gibby Foundry Co., Boston.
DEEMS, G. M., superintendent, Elmwood Castings Co., Cincinnati.
DEGLER, M. J., salesman, Tabor Mfg. Co., Philadelphia.
DEISHER, J. B., melting foreman, T. H. Symington Co., Rochester, N. Y.
DE LONG, J. A., Eastern Malleable Iron Co., Troy, N. Y.
DENNEGAN, A. I., foundry superintendent, Power Specialty Co., Danville, N. Y.
DILLER, H. E., chief of testing laboratory, General Electric Co., Erie, Pa.
DIXON, F. M., foundry superintendent, General Electric Co., Pittsfield, Mass.
DOBBINS, D. M., treasurer, Marshall Furnace Co., Marshall, Mich.
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